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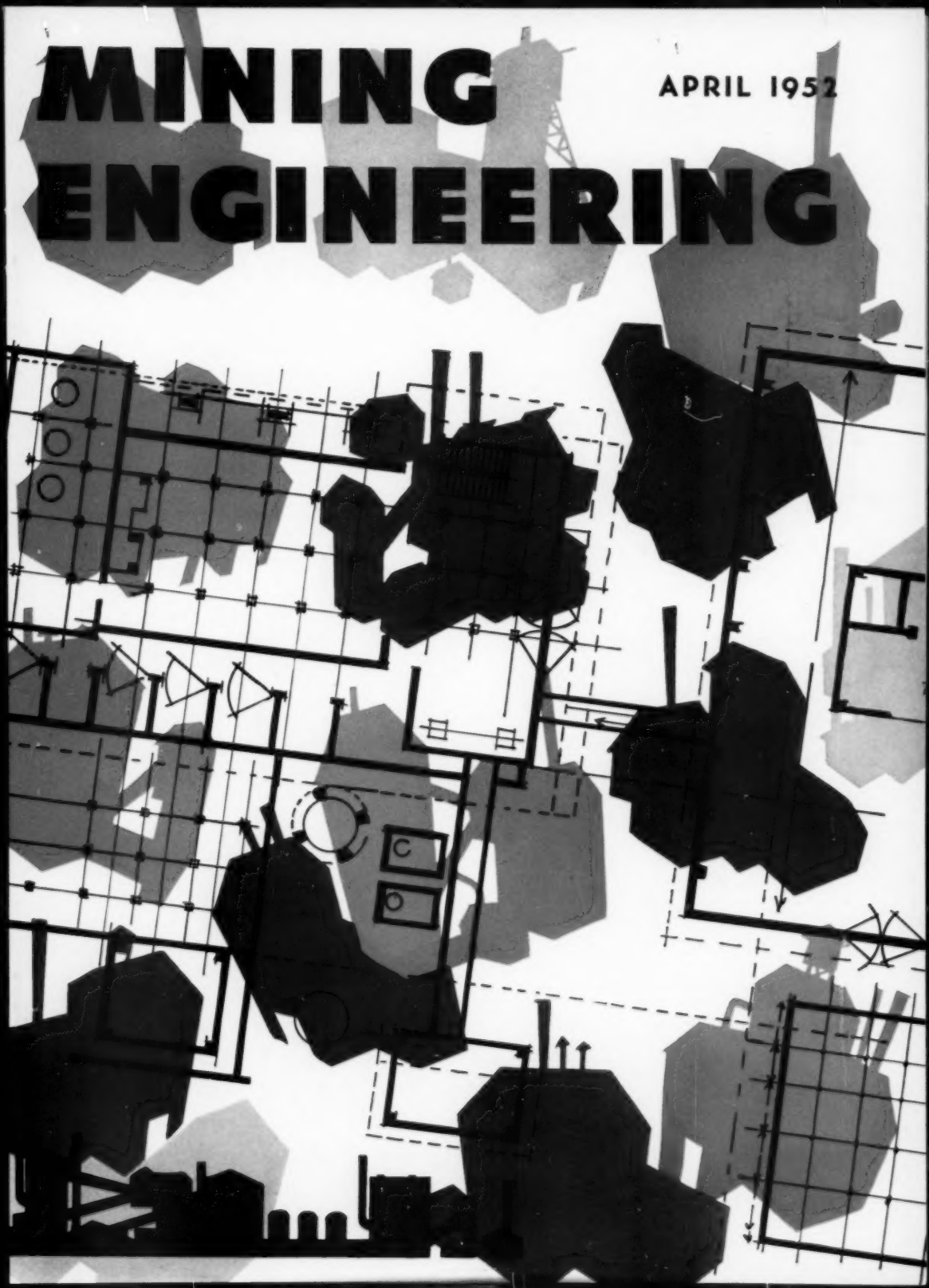

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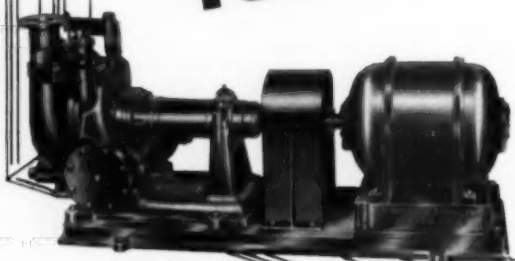

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VOL. 4 NO. 4 APRIL, 1952

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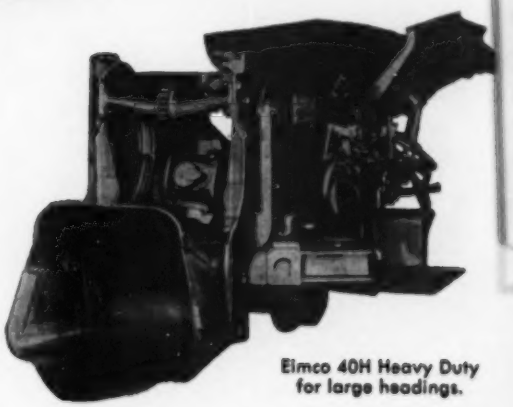

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Letters to The Editor

POINT OF NO RETURN?

For the past several years the policy of a large section of our mining industry in relation to our present bureaucratic form of government has become increasingly amusing, if not a little disgusting. In the past, mining men have always featured themselves the self-announced champions of free enterprise, and, generally, this conviction was substantiated by their deeds. In recent years, however, a large group of the industry, while still expounding, from the front porch, the principles of free enterprise and a sound economy based upon the law of supply and demand, have gone around to the back door with palm extended, to join labor, farmers, bureaucrats, and other pressure groups to get their share of the take. The procurement of subsidies, bonuses, increased metal prices, and government assistance in a multitude of forms seems to have obscured from their thinking the welfare of the country as a whole and the sounder economic principles of a balanced budget and lower taxes. At the recent Colorado Mining Association convention in Denver, I was alarmed to see just how far this special-interest type of thinking has progressed within the mining industry. Government assistance to mining was generally considered inadequate, and a flat bonus for any new mineral discovery was proposed. It was disquieting, too, to learn how far the federal alphabet agencies have entered into the mining industry and of the thousands of highly paid technical men on the federal payroll required to man these numerous overlapping agencies and bureaus.

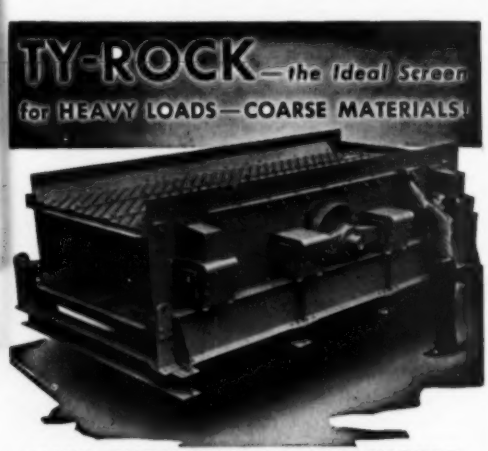
Now all this is very fine, and some aspects of the federal give-away program can be very appealing to the unsuspecting in the mining industry as they have been to those in other groups. Some of these expensive programs may bring about a few dividends or even several new mines. But to this whole line of pump-priming reasoning there is one big disastrous fallacy.

I have two children that I hope someday will be able to enjoy some of the opportunities that our type of government has afforded me in the past. But, at the present rate of deficit financing and government encroachment into private industry, it emerges as a plain, bitter fact to anyone who can add two and two and still get four that we will not be able to pass along to our children the same precious heritage which we have received from the preceding generations. We alone can be held accountable for this loss through our own short-sightedness and general lack of national moral principles. While decrying the socialistic policies of the present administration, we play into their hands by affording them the means and purpose for ever-increasing federal expenditures. We lose the control of our industries and our own self respect. Many of the government assistance programs, especially in mining, have been propagated in the name of national defense, and yet, when we have spent ourselves into economic chaos, we will be easy prey for international aggressors both from within and without.

Let's take a new look at ourselves and see if there isn't still time to regain some of the cherished birthrights which we inherited. As members of a traditionally fine industry founded by clear-thinking individualists in the past, let the mining industry lead the way in a return to the firm ground of sound economic principles that have given us the highest living standard in the world. The recent budget request for an astronomical 85 billion dollars has engendered a vociferous pressure from people in all walks of life throughout the country for a return to sensibility. Let other groups take their places in the everlengthening line for government hand-outs if they wish, but let's, at least, keep our own self respect. Instead of seeking bonuses, subsidies, and other gifts from this gigantic give-away program, sit down, tonight, write your congressman and insist that the federal budget be brought within the realm of sanity, insist that excessive taxation is already stifling the growth of our industries, insist that the socialism of our economy must cease, and insist that we cannot possibly support half the lackadaisical population of the world, who only hold us in contempt in return for our extravagances. Don't sit serenely by these next few months, but take an active, aggressive part in ridding our government of the parasitic, star-gazing group of economic crackpots who hold our very destinies within their soiled hands. It's late, but not too late, for each of us in the mining industry to overlook our dividends for a minute and consider our children.

FRED H. HOWELL
CLIMAX, COLO.

Amen! —Editor



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Letters to the Editor

Where Are The Jobs?

I have just finished reading Professor Bator's letter concerning hiring interviews. Until now I thought the situation which he discusses existed only in the East. We have heard that there are an abundance of jobs beyond the Mississippi. I still feel that positions with many mining companies are available, but how is one to know where these jobs are located?

Since college freshman days, I and other students have read engineering pamphlets and heard mining engineers extolling the tremendous opportunities awaiting men entering the mineral profession. I do not believe that all of those words we read and heard were mere talk for the sake of talking. What has become more apparent is that there is a missing link in the chain of communication of the industry. I arrived at this realization last year, when the senior class of my school, Lafayette College, Easton, Pa., was interviewed. Mining engineers received few interviews compared with other engineering students. Upon questioning, the placement Bureau informed us that it had always been much the same in years past.

In line with my feeling that jobs are to be had, based on literature and the words of visiting mining engineers, I have a suggestion to make which may go a long way toward solving the communication problem. I suggest that mining companies and members of the various senior classes take advantage of AIME membership, using the Institute as a clearing house or contact point.

Perhaps my suggestion is somewhat belated. If such a procedure is already in use, I would like to know about it.

Recently, members of the National Coal Association came to Lafayette. Our visitors advised us not to become discouraged and that all of us would have jobs. We appreciate the life given to the somewhat stifled spark of hope within us, but what happens now?

Our placement bureau here is an efficient one, and we would like to make use of it. It is our clearing house while we still have classes to attend, reports to write, and the other tasks the student must complete.

Professor Bator said, in his letter, that it isn't right for a man to spend four years preparing for a place in the mineral industry, only to have to compromise by taking a position in some other branch of engineering. If the mining industry is truly crying for engineers, we have not heard or seen its wails of woe.

It is my sincere hope that the mining industry will take effective measures to keep mining engineers in the mining industry and vitally interested in the field for which they are trained.

ROBERT S. LEIGHTON, '52
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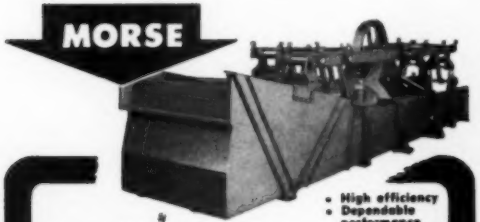

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MEET THE AUTHORS

B. R. Coil *(Electrical Installations at the Miami Mine are Cheaper with Flexible Cable, P. 356)* was born in Higginsville, Mo., and attended McKinley High School and Missouri School of Mines. He received a B.S. in mining engineering. Mr. Coil has worked for the Braden Copper Co., Rancagua, Chile as junior engineer and foreman. He was employed by Miami Copper Co. as a jigger boss, shift boss, development engineer and mine foreman. He worked as mine superintendent and general superintendent of the Castle Dome Copper Company, Inc. Mr. Coil may be reached at Box 100, Miami, Ariz. He is an AIME Member. Mr. C. R. Ross was co-author with Mr. Coil in the preparation of this paper. His paper covers the present installation of electrical equipment in block caving stopes along with background data. In this paper he has given one solution to wiring problems in heavy stopes.

J. K. RICHARDSON

J. K. Richardson *(Economics, P. 351)* was born in Glasgow, Mo., and attended New Mexico Military Institute, Roswell, N. Mex. and Missouri School of Mines. He received a B.S. and E.M. degree. He has worked for U. S. Potash Co., Carlsbad, N. Mex., as assistant chief engineer, research (flotation) engineer and safety director. He was with Climax Molybdenum Co., Climax, Colo. as director of safety and industrial hygiene. Mr. Richardson was secretary and manager of Tri-State Zinc & Lead Ore Producers Assn., Picher, Okla. and was also secretary and manager of Utah Mining Assn. He was industrial relations engineer with Western Mining Div., of Kennecott Copper Corp. In January 1952 he was made assistant to general manager in charge of public, industrial and labor relations, Utah Copper Div., Kennecott Copper Corp. An AIME member, he resides in Salt Lake City.

A. K. Schellinger *(Solid Surface Energy and Calorimetric Determinations of Surface-Energy Relationships in Some Common Minerals, P. 369)* was born in Dawson, Yukon Territory, Canada and attended Stanford University. He received A.B. degree in engineering in 1940 with distinction and Ph.D. in metallurgy in 1950. Mr. Schellinger has worked as assayer and metallurgical engineer with Treadwell Yukon Corp., Mayo, Yukon Territory, Canada from 1938 to 1939. He was junior metallurgist with American Smelting & Refining Co., Selby, Calif. from 1940 to 1941. He was employed by Andes Copper Mining Co., Potrerillos, Chile from 1941 to 1945. He is an instructor and assistant professor of metallurgy at Stanford University, School of Mineral Sciences at present time. Problems of special interest to him are rationalization of mineral grinding and crushing. He has presented four other papers before the AIME. Besides holding membership in AIME, Mr. Schellinger is a member of Sigma Xi and Tau Beta Pi. Fishing, hunting, and mountain climbing are his favorite hobbies.

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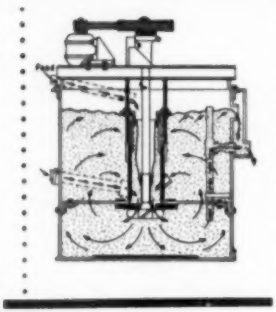

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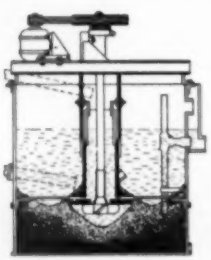

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A. J. WILLIAMS

A. J. Williams *(Saskatchewan's Industrial Minerals, P. 396)* was born in Enderby, British Columbia and attended Saskatoon High School and the University of Saskatchewan. He received a B.S. in chemical engineering in 1937. He has worked for the Chromium Mining & Smelting Corp. from 1938 to 1941. Mr. Williams was with the General Engineering Co. in Scarboro, Ont., from 1941 to 1946. From 1946 to 1947 he was with Shatford Christo Consolidated Geologists at Red Lake, Ont. At present he is with the Saskatchewan Dept. of Natural Resources, Regina, Ont. Development and efficient utilization of industrial minerals is of special interest to him. Photography, golf, and bridge are his favorite hobbies. Mr. Williams is a member of the Engineering Institute of Canada, and Saskatchewan Association of Professional Engineers. This is the first paper Mr. Williams has presented before the AIME.

E. E. Donath *(Chemicals from Coal Hydrogenation, P. 381)* was born in Sternberg, Germany and attended the University of Breslau, Germany. From 1926 to 1946 he was employed by Badische Anilin Und Soda Fabrik, Ludwig-Shafen as chief chemist for research. From 1947 to 1949 he was with the Bureau of Mines in Louisiana. Since 1949 he has been with the Koppers Co., Pittsburgh, Pa. in the Research Dept. Mr. Donath has presented a previous paper before the AIME entitled, "Coal Preparation for Synthetic Liquid Fuels" with co-authors. He holds membership in the American Chemical Society.

Vard H. Johnson *(Thermal Metamorphism and Ground Water Alteration of Coking Coal near Paonia, Colo., P. 391)* was born in Pleasant Grove, Utah and attended Brigham Young University, University of Utah, Stanford University, and University of Arizona. He received a B.S. in 1932, M.S. in 1933 and Ph.D. in 1941. His honors include a fellowship with University of Arizona and he was a scholar with Utah Mines. Mr. Johnson worked as junior engineer and geologist from 1936 to 1939 with Park City district. He was with U. S. Bureau of Mines as sample foreman in 1942. He served in U. S. Army from 1942 to 1943. From 1943 to present time he has been a geologist with U. S. Geological Survey. He holds membership in AIME, Geological Society of America and Utah Geology Society. Photography and woodworking are his favorite pastimes.

G. L. Simard *(Radiotracer Studies of the Actions of Dithiophosphate in the Selective Flotation of Galena and Sphalerite. Co-author with C. M. Judson, A. A. Lerew, J. S. Kennedy, and R. B. Booth, P. 375)* was born in Lewiston, Maine and attended the Massachusetts Institute of Technology. He received a Ph.D. degree. He has worked for Battelle Memorial Institute from 1938 to 1943. From 1943 up to present he is working for the American Cyanamid Co. Problems of special interest to him is surface chemistry. Mr. Simard has presented previous papers before the AIME. Mr. Simard is a member of the American Physics Society and the American Chemical Society.

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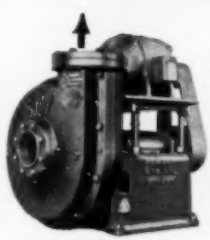

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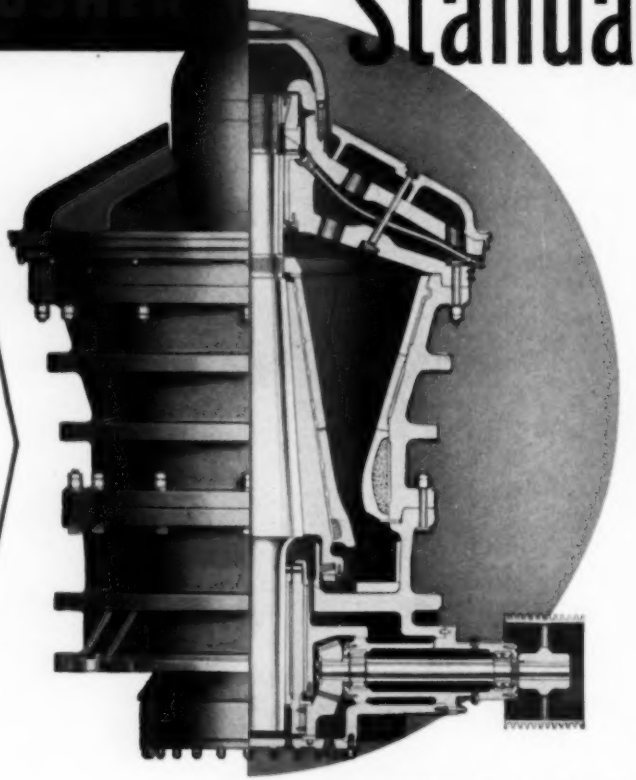

Improved lubrication throughout, including spider.

Sturdy all-steel construction . . . with heavy external ribbing.

Greater operating flexibility than any comparable crusher. Eccentric setting and speed can be varied to suit your capacity requirements.

More effective dust seal.

Vertical adjustment compensates for wear and maintains uniformity of product by means of adjustable spider suspension or *Hydroset* control. This hydraulic control permits quick product size setting and makes it easy to clear crushing chamber after shutdown.

Easy-to-replace, long life bearings.

Free-fall discharge.

THE *SUPERIOR* CRUSHER — with all these important features — requires fewer manhours to maintain . . . results in less shutdown time . . . less in the way of maintenance. And, whether on primary or secondary crushing, it will produce these savings for years to come. The A-C representative in your area will give you complete, detailed information. Call him, or write: Allis-Chalmers, Milwaukee 1, Wisconsin. A-3648

Superior and *Hydroset* are Allis-Chalmers trademarks.

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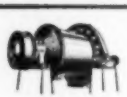
Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.

Hammermills

Jaw Crushers

Gyratory Crushers



Grinding Mills

Vibrating Screens

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3 way gear-up...

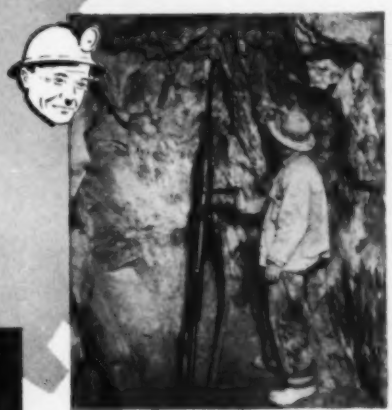
with the GARDNER-DENVER RB STOPER

puts your drill runners in high gear

Lets them drill more footage—produce more ore—thanks to perfect balance, easy holding characteristics, fast penetration, and automatic cleaning that eliminates clogged air screens.

meshes with your foremen's safety program

Helps them eliminate dry drilling. The desirable water-on—air-on—air-off—water-off cycle is automatically assured by the single throttle control valve.



won't clash with your drill doctor's schedule

The RB stays down in the stope between routine inspections—thanks to tough construction and the automatic air flow that constantly keeps sludge and cuttings out of the chuck end.

For greater safety—increased production and lower costs—select the RB Stoper for your mine—either the heavy-duty RB104 or the lightweight RB94. Write today for full details.

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Gardner-Denver Company, Quincy, Illinois
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THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS

Personnel Service

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18**; 100 Farnsworth Ave., **Detroit**; 57 Post St., **San Francisco**; 84 E. Randolph St., **Chicago 1**. Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining and Construction Engineer, B.S. mining engineering, 28, married, no children, excellent health, working knowledge French and Spanish. Five years' experience, underground and open-pit engineering and production, including 19 months Philippines; field layout and office work in construction engineering. Desire position foreign or southern U.S.A. Available immediately. M-673.

Mining Engineer, 48, married, one child. Several years' experience, exploration, development, and operation of gold and base metal properties. Thoroughly experienced underground work. Excellent health. Working knowledge Spanish. Registered professional engineer. Employed, available thirty days. Any reasonable location considered but cannot go single status. M-674-412-E-8-San Francisco.

POSITIONS OPEN

Resident Engineer with at least 20 years' mining experience covering shaft sinking and tunneling. Salary, $12,000 to $15,000 a year. Location, Nevada. Y6755(b).

Assistant Professor, young, with at least an M.S. degree in mining engineering or equivalent, to assist in teaching mining courses. Will attend to the preparation of course outlines, some correspondence, and final examinations for the mining extension courses given in the field by qualified mining engineers. Position starts July 1 or Sept. 1, 1952. Salary dependent on experience. Location, South. Y6739.

Field Geologists or Mining Engineers for a two year exploration project for tin placer deposits in Brazil. Y6719.

Mining Engineer, young, to act as assistant mine superintendent for nonmetallic open-pit operation in the South. Salary, $5000 a year and up. Y6703.

Mine Foreman for graphite mine in Ceylon. Must be well versed in electrical, diesel, compressor and rock drilling units. Y6117.

Engineers. (a) Mine Foreman with block caving experience and knowledge of Spanish language. Salary, $6600 a year. (b) Junior Metallurgist. Salary, $4000 a year. (c) Mill Superintendent. Salary, $5000 a year. (d) Mine Foreman, to supervise vein mining. Should have general experience in mine operations, particularly shrinkage and cut and fill methods of mining. Salary, $6000 a year. Three year standard contract. Location, Bolivia. Y5931.

Mining Engineer with coal production and preparation experience, to supervise installation, operation and maintenance of coal preparation plant. Salary, $12,000 a year. Duration two years. Location, Turkey. Y5891.

Mining Engineers. (a) Placer Development Engineer, 40 to 45, experienced in operation of dragline gold dredges, hydraulicking, sluicing, underground gravel mining, high list pumping—diesel and steam, etc., to function as resident engineer at large placer gold mine. Salary, U. S. $7000 a year in U. S. currency, tax exempt. Three year contract. (b) Mining Engineers, 3, 30 to 40, experienced in exploration and examination of placer goldfields for work in placer goldfields. Salary, U. S. $4800 a year in U. S. currency, tax exempt, quarters and living allowance. Two year contract. Temperate climate. Location, Ethiopia. Y5574.

Geologists with five to ten years' experience in mineral examination and exploration work. Salary dependent upon experience. Location, domestic and foreign. Y5182.

Engineers. (a) Mill Superintendent with minimum of five to ten years' experience in mill for metal mining company. (b) Assistant Mining Engineers for metal mining operations in the Philippine Islands. Salaries open. Y5022.

Junior Mine Engineer, recent college graduate, competent underground surveyor and draftsman. Standard three-year contract, single, free transportation furnished by air, four weeks vacation yearly plus free living quarters. Salary, $3300 a year plus yearly bonus. Location, Bolivia. Y4872.

Assistant Concentrator Superintendent for large mining company. Must have had considerable experience with lead, zinc and copper concentrators. Spanish helpful. Three-year contract, transportation, living quarters. Location, South America. Y6684.

Engineers. (a) Mine Foreman with at least three years' underground experience for lead-zinc operation. Salary, $4800 a year plus housing and family accommodations. (b) Shift Boss preferably engineering graduate, with underground experience. Salary, $4200 a year plus housing and family accommodations. Must speak Spanish. Location, Peru. Y6679.

Mining Engineer to take care of management and supervision of four small mines running from 75 tons per day up to 400 tons a day. Must be able to speak Spanish and get along well with native help. Salary open. Location, South America. Y6590.

NEED

PHYSICISTS
AND
ENGINEERS
FOR
RESEARCH AND DEVELOPMENT

In the fields of geophysics and well logging. Work includes the measuring, telemetering, recording and evaluation of electric, magnetic, acoustic, radioactive and other characteristics of earth materials. Laboratory located in Houston, Texas.

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In Los Angeles Contact:
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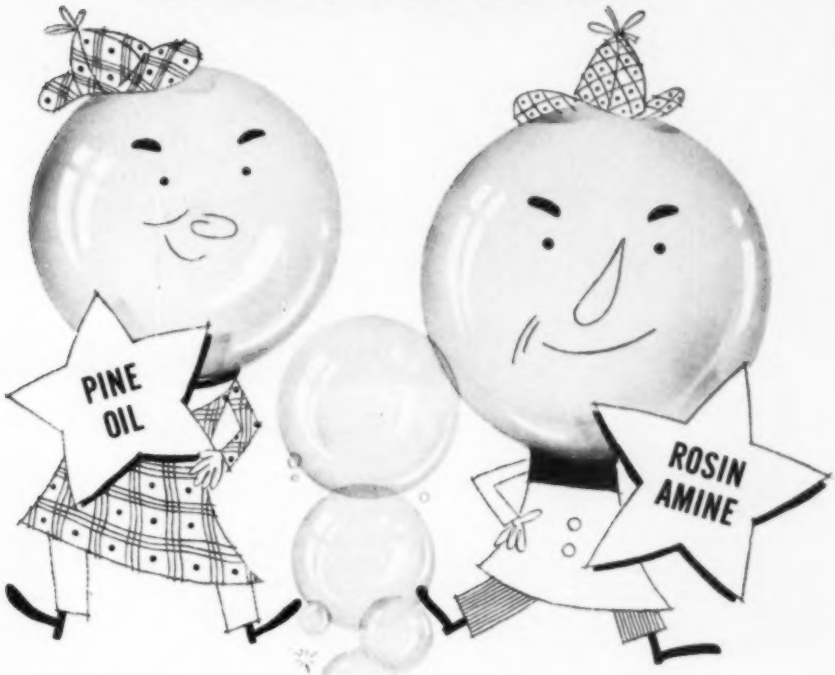
Position Vacant. Superintendent: Man familiar with open-pit mining with bulldozer, scraper, shovel, for New Caledonia. Some knowledge of French preferred. Must be able to teach operators. Liberal pay and bonus.

Box C-5 MINING ENGINEERING

WANTED
USED BLUEPRINTING EQUIPMENT
IN GOOD CONDITION
Box B-4 MINING ENGINEERING

Use these "Agents"

FOR BEST RECOVERIES



Frothers

HERCULES YARMOR® F PINE OIL
Standard of quality among pine oil frothers since the early days of flotation. Yarmor F Pine Oil produces a strong froth of good volume, satisfactory texture, and excellent cell-life stability.

Collectors

RADA (Hercules Rosin Amine D Acetate)
Siliceous mineral collector that has good solubility and handles easily.

Rosin Amine Derivatives: Special purpose collectors; uses vary with type of materials to be floated.

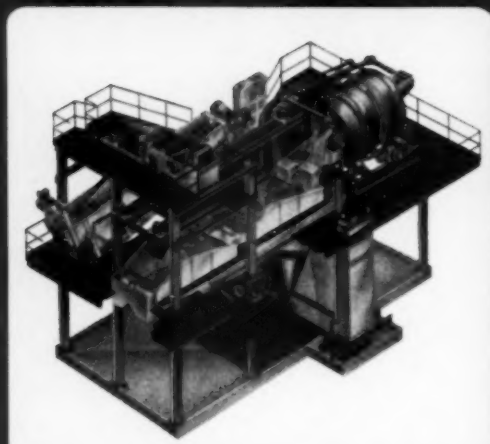
Technical information on these and other flotation aids is available. Send for 16-page booklet "Flotation and Hercules Flotation Agents."

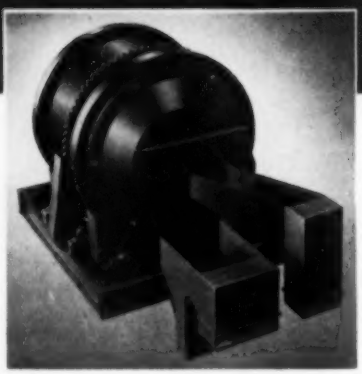
HERCULES Flotation Agents

HERCULES POWDER COMPANY Naval Stores Department, 955 King Street, Wilmington 99, Delaware

NM52-1

WITH **WEMCO'S** NEW
DRUM SEPARATORS





7 MOBIL-MILL ADVANTAGES

- *Prefabrication*
- *Low initial cost*
- *Clean, sharp separation*
- *Fast Wemco erection*
- *Compact design*
- *Low operating cost*
- *Capacities, 5 to 275 T P H*

• **THE SINGLE DRUM SEPARATOR**

For one stage Heavy-Media Separation, the single drum provides positive sink removal, low attendance requirements, close control of media density and lower horsepower consumption.

Sink material is removed by integral lifters in the rotating drum; the float material overflows the drum discharge weir. A minimum of media is carried over with the products, decreasing the investment in media reclaiming equipment.

• **THE DOUBLE DRUM SEPARATOR**

In treating those ores where a middling component must be segregated, Heavy-Media Separation can now accomplish this added separation with new economy and **positive gravity control.** The **WEMCO** Double Drum Separator uses a medium at two different gravities in separate compartments. Two stage separation is gained with decreased capital outlay and lower operating costs.

In a typical operation, feed is received by the first compartment which overflows a true float product and sends sink material directly to the second compartment. There a heavier gravity medium floats the middling product and submerges the true sink.

Both the true sink and true float are purer products than those produced by single stage operation, and the middling is cycled to recrushing and further separation.

Write today for further information on **WEMCO** *Mobil-Mills and drum separators.*

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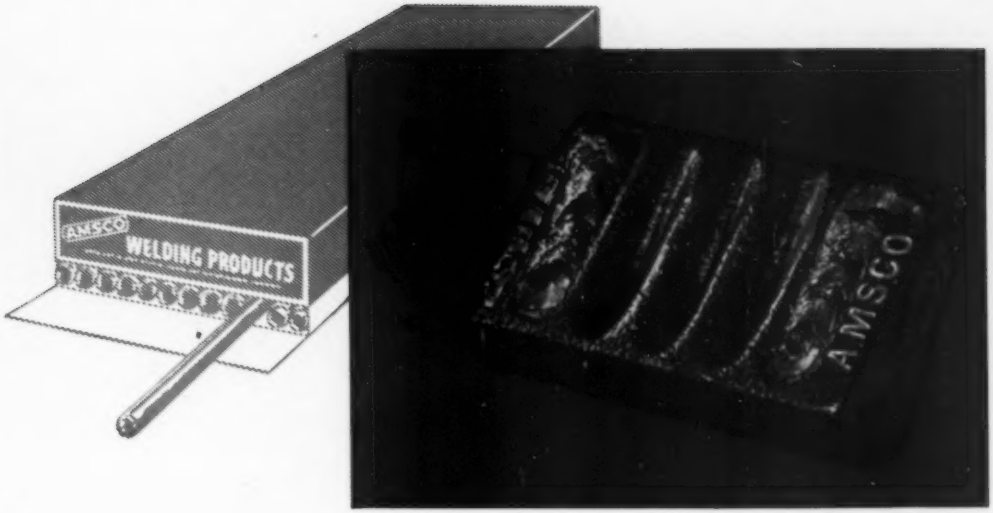


NOW! Wear your point and have it too!

This new catalog can help you save money on repair costs . . .

It's packed with information on the new "Wear-Sharp"—and the entire AMSCO Weldment line. Complete with installation instructions and helpful hints on welding. Be sure to ask for your free copy.

AMSCO "Wear-Sharps" are available in two quickly and easily installed types:

Crescent Back
For application to worn tooth with minimum fitting.

Straight Back
For application after worn tooth is beveled.

U.S. Pat. No. 2,247,202

New AMSCO "Wear-Sharp" repointer holds a straight edge as it wears . . . and stays sharp longer!

Here's a new tooth repointer that is just what you've been looking for . . . the AMSCO "Wear-Sharp", *and it does exactly what the name implies.*

Note the groove design on this new repointer shown above. The outside and end grooves are AMSCOATED with Amsco Hardfacing Electrodes specially recommended for this purpose, while the inner grooves are left as they are. Result?

The Amscoated grooves wear slower, thus equalizing wear along the entire cutting edge and making the point stay sharp longer. Rounded, blunted corners that cut digging efficiency and waste power are completely eliminated for the life of the repointer!

The "Wear-Sharp" is already setting new records in service life and digging efficiency. For example, an Eastern mine reports *6 times longer service than any repointer ever used before.*

The next time your dipper teeth need repointing, try the new "Wear-Sharp"! Write today for illustrated catalog shown at left—and name of your nearest AMSCO Distributor.

AMSCO WELDMENTS
THE RIGHT WAY TO MAKE REPAIRS

Brake Shoe AMERICAN MANGANESE STEEL DIVISION
417 EAST 14th STREET • CHICAGO HEIGHTS, ILL.

Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.
Amsco Welding Products distributed in Canada by Canadian Liquid Air Co., Ltd.

Shovel

To further increase the efficiency in the production of their foundry sand, the *American Silica Sand Co.* has purchased a new and improved shovel that will be used for loading trucks at their Reynolds Pit. The

new shovel will greatly facilitate winter mining operations and make possible larger winter shipments of the company's foundry sand. The Reynolds Pit is one of three sand pits in the Ottawa district owned by American Silica which produce sand that is refined for foundry use. **Circle No. 1**

Electric Switches

The Crane Electric Co. has just announced the production of their R-1000, a new rotating limit switch designed to control the travel of any rotating device requiring interruption or establishment of electrical current after a predetermined number of revolutions. It is useful for machinery, lifts, and other power equipment. The switch is presented in a finished case, 16 gage, reinforced, with walls of sufficient strength to hold the entire mechanism and all the parts in accurate alignment. The worm gear combination has a 60 to 1 ratio, sufficient for most industrial uses. The number of revolutions can still be increased by using various combinations of driving sprockets, either on the shaft of the switch, or on the sprocket of the unit controlled by the switch itself. **Circle No. 2**

Electric Trailer

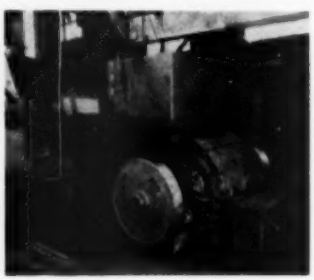
The Mercury Mfg. Co. announced the availability of a newly-designed heavy-duty electric tractor for use in industries where material handling is a significant factor. The new unit, Model A-800-4, is powered by two high-capacity series-wound enclosed motors capable of delivering 800 lb normal and 5500 lb maximum drawbar pull. The four-wheel drive, four-wheel steer unit is controlled by an automotive wheel-type steering assembly and a foot pedal accelerator. It has four travel speeds in either direction. Its directional control is conveniently mounted on the steering column. The drive axle assemblies consist of double-reduction, spiral bevel and spur gear units with standard four-pinion differential. **Circle No. 3**

Drilling Tools

For drilling long holes varying in depth from 20 to 150 ft, *Rock Bit Sales & Service Co.* offers a complete set of tools for use with the standard percussion type rock drills. These tools include: True-Seal shank, adapters, couplings, extension rod and Rok-Bit tungsten carbide bits. They are for use in drilling grout holes, test-holes, sub-level bench stoping holes or blast holes of standard diameters. Such holes can be drilled in any type of rock or ore and in any direction. Based on over a year's field operation, the manufacturer claims the coupling and adapters are designed to be self-cooling and self-cleaning. The tool's design keeps the hole in alignment and eliminates excessive vibration at maximum depth. **Circle No. 4**

Crusher

The new American 30-S heavy duty crusher is designed as a primary crusher, reducing coal and impurities prior to going to the washery. According to the manufacturer, the heavy duty 30-S gives more efficient and lower cost coal preparation by its ability to crush ROM coal, rock, slate, sulphur balls



and "gob" to minus 8 in. or minus 6 in. without oversize and without choking up regardless of the toughness of the materials included in the ROM coal. The saving in labor cost of pickers is an advantage claimed for this new crusher. At installations already in operation picking operations have either been eliminated completely or reduced by two-thirds of previous costs. *American Pulverizer Co.* **Circle No. 5**

Conveyor Belting

In order to get the maximum service life out of conveyor belting, industrial users should take particular care to repair all belt damage as soon as it is discovered. An adequate repair kit includes sharp cobbler's knives and a stone to keep them sharp; a supply of emery cloth, rubber cement, inner tube patching rubber, rip plates and standard belt fasteners and accessories. These tools are available from Newell Perry, engineer of *Thermoid Co.* To mend long and deep cuts which go through to the fabric, open the cut, clean out all dirt, and cement the cut closed, allowing the cement to dry thoroughly before the belt is restored to service. Where gouges have penetrated the belt, or longitudinal rips have occurred, these points must be cleaned, sanded, cemented and reinforced with rip plates at three-inch intervals. **Circle No. 6**

Diesel Locomotives

The Mancha Storage Battery Locomotive Division of *Goodman Mfg. Co.* is now offering diesel powered locomotives for use in metal mines and tunnels. Illustrated here is a 4-ton unit powered by a 45 hp engine which drives through a torque converter. Running speeds are from

3½ to 7½ mph depending upon the drawbar pull demand. This locomotive is operating in an Eastern base metal mine on 24 in. gage and has over-all dimensions of 42 in. width, 55 in. height and 9 ft 4 in. length. Exhaust gases are effectively conditioned by a water scrubber to prevent causing any discomfort to underground personnel. **Circle No. 7**

Fork Lift

Development of a 5-ft power driven fork lift attachment for the MOTO-BUG has been announced by *Kwik-Mix Co.* The new materials handling device has a capacity rating of 1000 lb at 15-in. load center. Designed to answer handling problems in construction work, the new fork lift unit operates from a power driven hydraulic pump. For maneuvering the operator rides on rear step, has full power forward and reverse. A large steering wheel is connected directly to the dual rear wheel through a 3.6 to 1 gear reduction. Equipped with a standard make 6 hp gasoline engine, power is transmitted by V-belt and roller chain through an automotive type differential in the front axle. **Circle No. 8**

Free Literature

(9) DIESEL TRACTOR: The D2 4-stroke cycle Diesel engine is built for powering the D2 tractor. It has the stamina to take heavy, continuous loads without costly breakdowns. There are only two operating adjustments for the Cat D2 engine. These two adjustments are fan belt tension and valve clearance. The fuel filter on the D2 engine is of the cotton yarn-wound absorbent type. It protects the finely finished parts of the fuel injection system from harmful abrasive particles. The D2 governor keeps power output matched to the load on the engine and is designed to give quick response to sudden load changes. The roomy seat of the D2 is provided with a comfortable individually wrapped coil spring, foam rubber cushion making it comfortable for the operator. *Caterpillar Tractor Co.*

(10) WELDING: This attractive booklet covers such topics as design information, selecting the proper heating medium, welding procedures and inspection and control. The chapter under advantages of various methods of heating covers torch, arc, induction and furnace joining methods. Arc joining can be roughly divided into two categories: carbon arc welding and metallic arc welding. Induction joining presents a method of metal fabricating that is ideally suited to mass production of small to medium sized parts, where the fairly large investment in equipment is warranted. After being polished and etched, a cross-section of a weld will yield much in the way of quality control information. *Eutectic Welding Alloys Corp.*

(11) DRIVES: Pointing up the cost-reducing advantages that packaged, all-electric, adjustable-speed drives bring to a wide range of production machines and processing equipment, a new 8-page booklet has just been issued by *Reliance Electric & Engineering Co.* Briefly discussed are seven basic functions of the effective method of power transmission, available in drives of five types ranging in ratings from ¾ all the way up to and including 200 hp. Supplementary information includes diagrammatic and tabular charts covering basic speeds and horsepower-torque characteristics of the drive.

(12) POWER SHOVEL: This booklet describes the *Marion Power Shovel Company's* new shovel. This shovel is a new 10 cu yd quarry and mining type machine which will load 50-ton haulage units in three or four passes. One of its impressive features is its ability to load these big haulage units in small machine cycle time. The operator controls the propel brakes electrically, and the brakes in turn are operated hydraulically. Dual propel brakes are equipped with brake linings having a high friction rating, speeding up response to the operator's controls. Two matching 187½ hp 600 line motors, with blowers, provide a total of 375 hp to operate the hoist machinery and through the use of clutches drive the propel mechanism.

(13) MOTOR CONTROL: A completely new motor control center for use wherever two or more ac motors (up to 200 hp, 600 v) are controlled from a central location has been announced by *General Electric's* Control Dept. The new center, pre-engineered, factory wired and assembled, and employing many standard components and accessories, was developed for use in steel, ore and processing plants. The center is designed to withstand short circuit stresses up to 25,000 amp, substantiated by laboratory tests. One of the main features of the new design, is a 4-in. vertical trough (with cable supports) which runs the full length of each section, providing ample space for wiring.

(14) WIRE ROPE ASSEMBLIES: These assemblies consist of a length of preformed wire rope with a terminal attached to one or both ends. The wire rope may be bright or galvanized carbon steel, stainless steel, or monel metal. Safe-Lock terminals are attached to the cable by a cold working process which causes the metal to flow into the valleys of the cable, forming a bond stronger than the cable. This booklet describes how to order these wire rope assemblies. The person ordering should specify the diameter, construction, and grade of wire rope. If description of wire rope is not known, explain the use of the assembly and ask for recommendations. This booklet illustrates by means of pictures and charts the points discussed. Available from *Macwhyte Company.*

(15) WROUGHT IRON: This booklet depicts in a nontechnical manner, a few installations which typify the corrosion resistance and durability of genuine wrought iron. Although there are literally volumes available, discussion of supporting technical data has been kept to a minimum. Such data is important of course, but to present it in such a general way would be of little help in solving any individual building or maintenance problems. The selection of a proper material demands careful study of the specific problems involved. Available from *A. M. Byers Co.*

(16) DRILLING: Recommended procedure for drilling long holes varying in depth from 20 to 150 ft with tungsten carbide Rok-Bits long hole drilling tools and the standard percussion type drills, is fully covered in a 4-page bulletin offered by the *Rock Bit Sales & Service Co.* Such holes can be drilled in any type rock or ore in any direction, the manufacturer indicates, in two standard dimensions, 1⅞ in. and 3 in.

(17) SNOW PLOWS: The complete line of truck mounted snow plows manufactured by *Baker Mfg. Co.* is described in Bulletin #1003. The bulletin describes Baker V-Type, reversible tripping blade and one-way tripping blade plows in a complete range of sizes. V-Plows are equipped with easily replaced, readily adjusted runners.

Mining Engineering **April**
29 West 39th St.
New York 18, N. Y.

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11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30

Students are requested to write direct to the manufacturer.

Name _____ Title _____

Company _____

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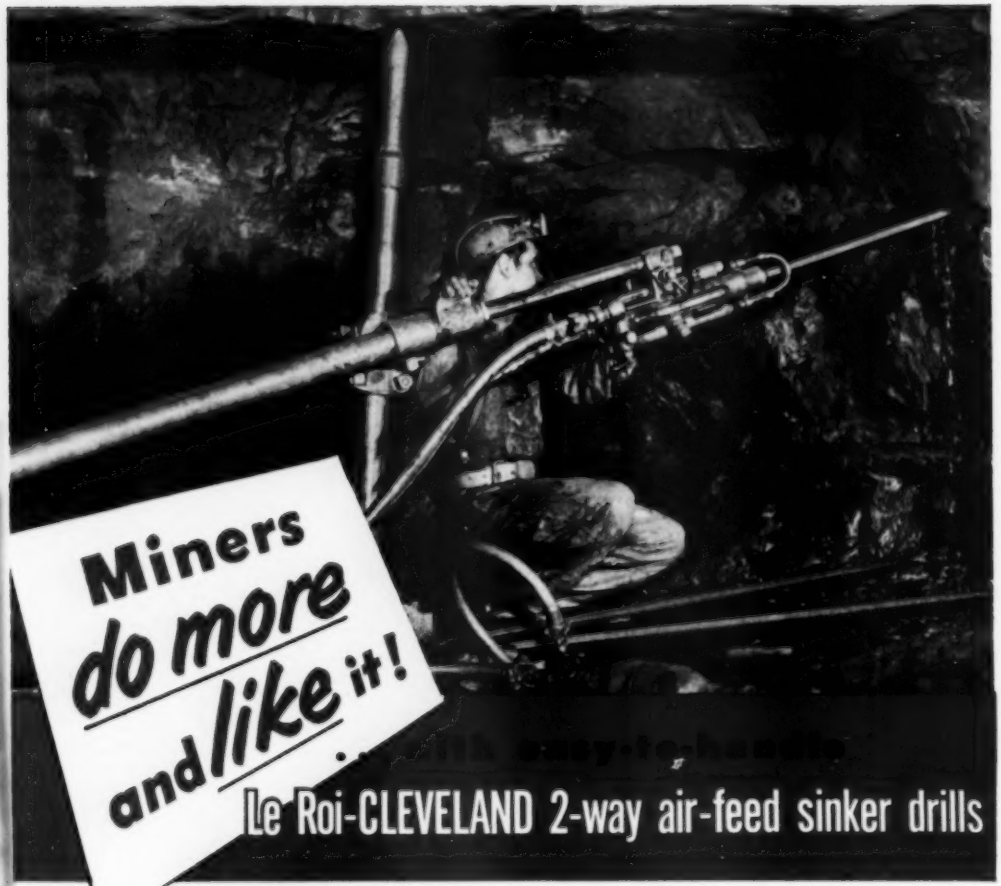

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Safety records improve!
Tonnages rise!

TAKE the hardest part of the work out of drilling and speed it up, too. Equip your miners with Le Roi-CLEVELAND HC10 Air-feed Sinker Drills — then watch tonnages per man-shift go up.

A lightweight column — pneumatic- or screw-type — supports the HC10. Setting-up takes only a few minutes. Feeding is done by air-pressure. All controls are handy.

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The fast, light blows of Le Roi-CLEVELAND Air-Feed Sinker Drills are just right for carbide bits. You get maximum bit life — can use smaller bits for higher drilling speeds.

In addition to the popular HC10 model with 45-lb. drill, Le Roi-CLEVELAND Air-feed Sinker Drills are available in an HC23 model with 3¼" bore. Both models help your miners produce more footage and greater tonnages. And because the men don't get so tired, safety records improve.

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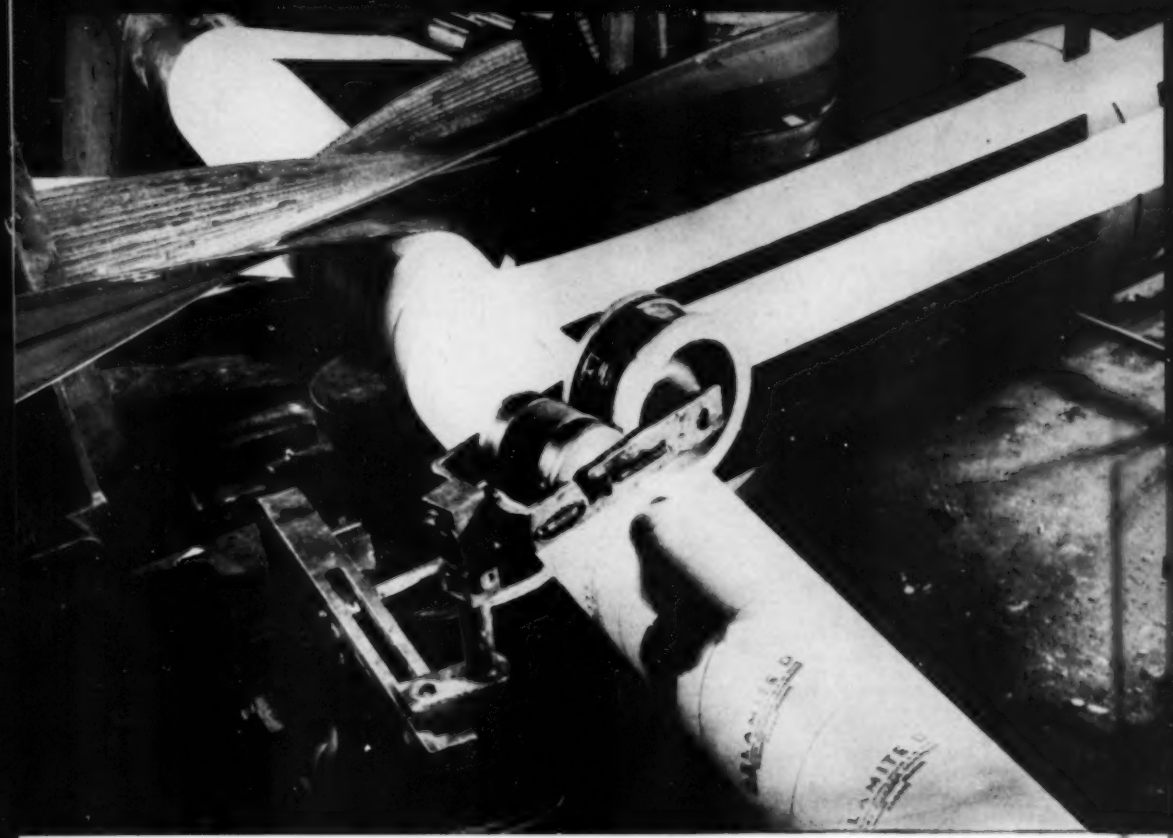
PROGRESS IN EXPLOSIVES . . .



DYNAMITE, KING-SIZE

Did you know that dynamite comes in cartridges this big? Hercules pioneered in developing these larger cartridges which make for efficient blasting in large-scale coal stripping, open-pit mining, and quarrying operations.

These king-size cartridges range in diameter from 1¼ in. to 11 in. and weigh as much as 60 lbs. when filled. Spiral-wrapped in Hercules' own plants, they offer advantages in rigidity and smoothness. Other advantages: They are essentially their own shipping containers, are easier to handle and use, and can be stacked like cordwood.

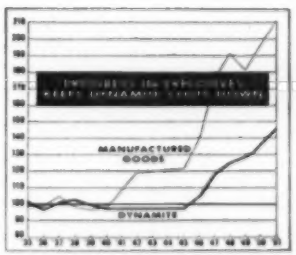


Chart shows relative stability of dynamite prices since 1935, as compared with prices of other manufactured goods. 1935-39 values=100.

HERCULES POWDER COMPANY

INCORPORATED

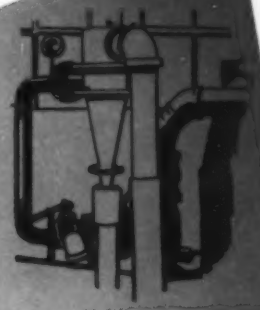
Explosives Department, 955 King St., Wilmington 99, Del.

X852-3

Here's the picture on REAGENTS AND PROCESSES for the difficult days ahead

Metal consumption both for re-armament and essential civilian use has yet to reach its inevitable all-time peak. But all production/consumption estimates now indicate that chemical beneficiation of greater tonnages from existing mines must be augmented by developing new, known ore-bodies. Thus, an assured supply of metallurgical chemicals and the application of improved processes are the very foundation stones of expanded metal output.

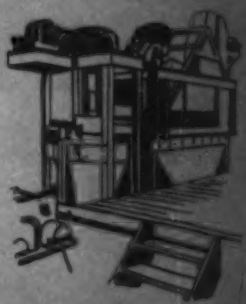
Long a leading industrial-chemical producer as well as an important source of reagents and treatment processes, Cyanamid has a mature understanding of the problems posed by a simultaneous upsurging demand for both metals and chemicals. Though no one can foresee, much less bind the future, Cyanamid has met and mastered similar problems in previous periods of world upheaval ... confidently expects to do so again.



When peace returns worldwide, we still expect to be able to say: No Cyanamid customer ever had to suspend production for lack of Cyanamid Reagents.

Specificially here is a high-spot inventory of what Cyanamid stands ready to provide its customers in every mining field:

REAGENTS As shown on the page opposite, Cyanamid offers a most complete line of cyanidation and flotation reagents. Notable specialized reagents have been added during recent years. Others are being aggressively researched. Production facilities are available for expected peak output.



PROCESSES With recent commercial operation of two Dutch State Mines Cyclone Separator plants to beneficiate iron ore fines in the ¼" x 65 mesh size range, Cyanamid now offers proven processes for a wide variety of ores in all size ranges from 6" to 0. These processes include: Heavy-Media Separation for 6" x 10 mesh feed; Dutch State Mines Cyclone Separator for the ⅜" x 65 mesh size-range, and Specialized Froth Flotation in the 65 mesh x 0 size range. Millions of tons of commercial experience with these processes, alone and in combination, have resulted in a tremendous fund of experience in their most efficient use.

TESTING AND APPLICATION SERVICE. Paralleling the growth of the Reagents and Processes offered, Cyanamid has simultaneously expanded its staff and facilities for technical service. To a greater degree than ever before, we can provide dependable, unbiased testing services prior to selection of the processes and reagent combinations needed to treat refractory ores. Likewise, we can give you practical on-the-mill help in applying recommended reagents and processes to your feed.

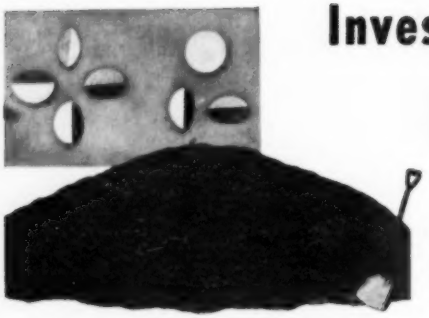
First step toward utilizing all the resources Cyanamid provides for its customers is a discussion of your problems and objectives with a nearby Cyanamid Field Engineer. Since he is in constant touch with headquarters, your letter or telephone call will bring his prompt and intelligent attention.

AMERICAN Cyanamid COMPANY

MINERAL DRESSING DIVISION

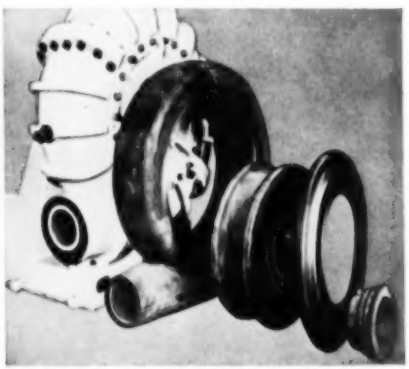
30 ROCKEFELLER PLAZA NEW YORK 20, NEW YORK

Printed in U.S.A.



SEE FOR YOURSELF why NI-HARD cuts grinding costs. Unlike other cast irons, NI-HARD is composed of a multitude of hard carbides firmly embedded in a matrix which is as hard as fully hardened steel. Ni-Hard balls are produced in sizes from $\frac{3}{8}$" to $1\frac{1}{4}$". Balls at left above are sectioned to show soundness.

THESE BALL MILL LINERS of chilled NI-HARD replace rolled steel liners for milling ores. The user previously used all types of liner materials, including manganese steel, chilled iron, etc., before standardizing on NI-HARD.



SOLIDS-HANDLING PUMP PARTS, produced to take full advantage of NI-HARD, include impellers, shell liners, suction side liners, engine side liners, throat and seal rings.

Investigate NI-HARD for your

ABRASION PROBLEMS

NI-HARD is produced by authorized foundries from coast to coast

Ni-Hard® . . . an abrasion-resisting nickel iron . . . has proved the answer to hundreds of problems involving severe abrasive wear. During the past 20 years it has set notable records for length of service, down-time saving and *ultimate economy* where wear-resistance is the primary requirement. A few typical Ni-Hard applications are illustrated.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of NI-HARD for many end uses in defense and defense supporting industries. There are authorized foundries, from coast to coast, equipped to produce NI-HARD castings in all common forms and shapes.

SOURCES OF SUPPLY FOR NI-HARD CASTINGS

EASTERN SECTION...

Plattsburg Foundry & Machine Co.
18 White St.
Plattsburg, N. Y.

Engineered Castings Div.
American Brake Shoe Co.
10 Mount Read Boulevard
Rochester 11, N. Y.

Brake Shoe & Castings Div.
American Brake Shoe Co.
230 Park Ave.
New York 17, N. Y.

American Abrasive Metals Co.
460 Cott St.
Irvington 11, New Jersey

Palmyra Fdry. Co., Inc.
Arch St. Station
Palmyra, New Jersey

U. S. Pipe & Fdry. Co.
Burlington, New Jersey

Hardinge Mfg. Co.
240 Arch Street
York, Pa.

Link-Belt Co., Olney Fdry.
180 W. Duncannon Ave.
Philadelphia 20, Pa.

New Castle Fdry. Co.
Mahoning Ave. & Hobart St.
New Castle, Pa.

The Pennebacker Co.
Emmaus, Pa.

Sprout, Waldron & Co., Inc.
Sherman St.
Muncy, Pa.

Treadwell Engrg. Co.
Lenox & 25th Street
Easton, Pa.

Weatherly Fdry. & Mfg. Co.
Commerce St.
Weatherly, Pa.

Georgia Iron Works Co.
605 12th St.
Augusta, Ga.

Pekor Iron Works, Inc.
P. O. Box 909
Columbus, Ga.

Thomas Foundries, Inc.
3800 10th Ave. No.
Birmingham 1, Ala.

CENTRAL SECTION...

The Brom Mach. & Fdry. Co.
3565 W. 6th St.
Winona, Minn.

Staver Foundry Co
Box 74
Virginia, Minn.

Bassett Foundry Co.
Adrian, Mich.

Calumet & Hecla Cons. Copper Co.
Calumet, Mich.

Engineering Castings, Inc.
405 S. Linden St.
Marshall, Mich.

The Babcock & Wilcox Co.
85 Liberty St.
New York 6, N. Y.
(Plant: Barberton, Ohio)

Brake Shoe & Castings Div.
American Brake Shoe Co.
109 N. Wabash Ave.
Chicago 4, Ill.
(Plant: Melrose Park, Ill.)

Frank Foundries Corp.
2020 3rd Ave.
Moline, Ill.

Griffin Wheel Co.
445 N. Sacramento Blvd.
Chicago 12, Ill.

Wells Manufacturing Co.
7800 N. Austin Avenue
Skokie, Ill.

Eagle Iron Works
129 Holcomb St.
Des Moines, Ia.

Helmick Fdry. Mach. Co.
8th St. & Belt Line
Fairmont, W. Va.

Carondelet Foundry Co.
2101
S. Kingshighway Blvd.
St. Louis 10, Mo.

Keller Foundry Co.
1010 E. Jackson Ave.
Knoxville, Tenn.

Arkansas Foundry Co.
1501 East Sixth St.
Little Rock, Ark.

WESTERN SECTION...

Eagle Foundry Co.
75 Horton St.
Seattle 4, Wash.

Union Iron Works
Box 2135
Spokane 2, Wash.

Caird Engineering Works
Helena St. & Montana Ave.
Helena, Montana

Pacific Ball Mfg. Co.
P. O. 106
Southgate, Calif.

Pacific Foundry Co., Ltd.
3100 19th St.
San Francisco, Calif.

Stanley Foundries
6009 Santa Fe Ave.
Huntington Park, Calif.

Capitol Foundry Co.
Phoenix, Arizona

Darbyshire Steel Co., Inc.
P. O. Box 352
El Paso, Tex.

Texaloy Foundry Co.
1407 Hoefgen
San Antonio 3, Tex.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Two Canadian mining companies, Noranda Mines, Ltd., and Wright-Hargreaves Mines, Ltd., have agreed to buy $500,000 worth of shares each in Anglo-American Exploration Ltd., controllers of thousands of acres of possible oil-rich land in southern Saskatchewan and Manitoba. Samuel Clarence Nickle, Sr., reported as possible president of the newly formed exploration company, said that $20 million in assets have been accumulated by the firm, mainly in the Williston basin in parts of the Dakotas and Montana, and extending into Southern Manitoba and most of Saskatchewan.

The M. A. Hanna Co. reported a record profit for the seventh consecutive year with total 1951 profit reaching $14,081. The company handled a record 16.8 million tons of iron ore in 1951, compared with 14.9 million tons in 1950. The company is also preparing to open four iron ore mines in the Lake Superior district which are expected to produce more than 5 million tons annually by 1954. The company built two new iron ore concentrating plants at Mesabi range mines in 1951, with a third plant going into operations soon.

The Office of Price Stabilization authorized ceiling prices of 50 pct above the highest prices sellers received for large dimension wooden mine materials during the May 24, 1950 and June 24, 1950 period. Shortages have been experienced in Michigan, Wisconsin, and Minnesota. New ceilings are provided in Amendment 1 to Supplementary Regulation 82 to the General Ceiling Price Regulation, effective February 19.

Venezuela announced discovery of bauxite fields containing an estimated 2 million tons of high quality aluminum ore. A spokesman said the fields were discovered by experts from the Venezuelan Ministry of Mines north of the village of Upata in Venezuelan Guiana last year.

Allis-Chalmers Mfg. Co. is starting to plan for construction of the world's largest crusher for the processing of taconite. The four story machine will take about two years to build, according to G. V. Moody, manager of the firm's processing machinery department. It will be installed in a plant to be constructed by the Reserve Mining Co., at Babbitt, Minn. Two 500-hp motors will drive the 1.25 million lb machine, which is expected to crush taconite at the rate of 3500 tons an hr.

Pittsburgh Consolidated Coal Co., completed two transactions involving lease and sale of coal mines and reserves in the Freeport field, northeast of Pittsburgh. Renton No. 6 mine at Newfield was leased to Republic Steel Corp. The mine contains about 3000 acres of metallurgical coal. In the second transaction, National Steel Corp. and Pittsburgh Consolidated combined acreages in the Freeport field and jointly leased approximately 6000 acres to a newly formed corporation, Renton Coal Co. The new firm is owned 60 pct by Pittsburgh Consolidated and 40 pct by National Steel.

from the PYRAMID OF KHUFU . . .

to the MESABI RANGE . . .

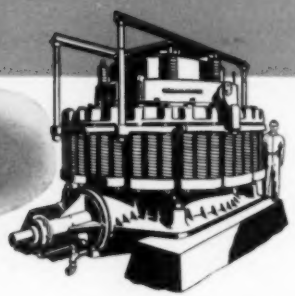
IRON
HAS COME
A LONG WAY

THE largest of the *Pyramids of Gizeh* is that of *Khufu*, built of limestone cut in the quarries of the Nile Cliffs and floated across the river to the site of the tomb.

It is claimed by some historians that the oldest iron to be discovered was in the form of a tool found in an air shaft of this great pyramid of Khufu, which was built about 2800 B.C. From Khufu to the modern marvel of the Mesabi Range, iron has come a long way . . . to become the metal of greatest service to man.

Since their introduction, "*SYMONS*" Cone Crushers, with their great capacity for more finely crushed ore at lower cost, have been a big factor in the production of iron ore . . . *and have achieved outstanding performance records in all of the great ore and industrial mineral operations the world over.*

NORDBERG MFG. CO., Milwaukee, Wisconsin



"SYMONS" Cone Crushers . . . *the machines that revolutionized crushing practice* . . . are built in Standard, Short Head, and Intermediate types, with crushing heads from 22 inches to 7 feet in diameter—in capacities from 6 to 900 tons per hour.

"SYMONS" . . . *A NORDBERG TRADEMARK KNOWN THROUGHOUT THE WORLD*

C352

"SYMONS" Primary Crushers

Grinding Mills

Mine Hoists

"SYMONS" Vibrating Bar Grizzlies and Screens

Diesel Engines

NORDBERG

MACHINERY FOR PROCESSING ORES and INDUSTRIAL MINERALS

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For Maximum Production

Match the JACKHAMER to the JOB!

This complete I-R line offers you a rugged, powerful Jackhamer for each type of service

Today's need for higher and higher production, with limited manpower, makes the *efficiency* of your rock drilling equipment more important than ever before. You get more footage per man hour—with minimum effort and fatigue—when you use an Ingersoll-Rand Jackhamer of the correct weight and power for the work to be done.

J-50 This heavy-duty, 60-lb. Jackhamer is best suited for drilling vertical holes up to 20 feet deep—in shaft sinking, excavation, road building and quarry work. It also makes an excellent light-weight drifter when used with Carset Jackbits.

J-40 This powerful, 50-lb. Jackhamer readily handles heavy-duty jobs in mines, excavation, trench and road work where the drill must be lifted or carried frequently. The J-40 with the JL4 Jackleg and Carset Jackbit combination is ideal for stope drilling in mines.

J-30 This rugged, 35-lb. Jackhamer is ideally suited for horizontal or semi-horizontal drilling in mines, quarries, construction jobs and industrial plants.

J-10 This 14-lb. Utility Jackhamer, complete with automatic rotation and hole blowing has many applications for light-duty drilling and can also be used with Carset steels, chisels, gouges, moil points and star drills.

CARSET JACKBITS All Jackhamers drill greater footage per man hour when Carset Jackbits are used. These I-R super-bits, tipped with tungsten carbide, outlast steel bit usages by as much as 400 to 1 — have negligible gauge wear — practically eliminate bit changes — maintain uniformly high drilling speed for the full depth of the hole.

635-5

FOR COMPLETE INFORMATION on all of these Ingersoll-Rand Jackhamers, write for your free copy of Catalog No. 4096.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

Sulphur

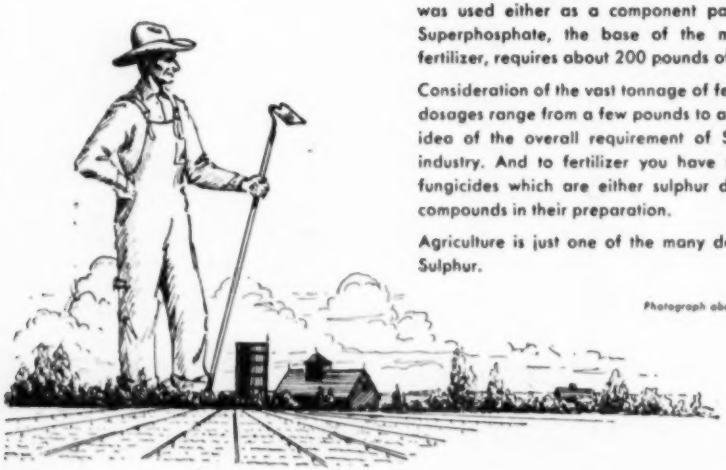
Thousands of tons mined daily, but where does it all go?

THE DEPARTMENT OF AGRICULTURE reports that in 1950 some 336,000,000 acres of land in the United States were under crop cultivation. That's a lot of acreage.

But where, you might ask, is the connection with Sulphur? Fertilizer, to take just one phase of agriculturally-used chemicals in which Sulphur was used either as a component part or as a processing element! Superphosphate, the base of the most widely used manufactured fertilizer, requires about 200 pounds of Sulphur for every ton produced.

Consideration of the vast tonnage of fertilizer used in agriculture — and dosages range from a few pounds to a ton or more per acre — gives an idea of the overall requirement of Sulphur for this one division of industry. And to fertilizer you have to add all the insecticides and fungicides which are either sulphur derivatives or have used sulphur compounds in their preparation.

Agriculture is just one of the many destinations of great tonnages of Sulphur.



Photograph above shows our loading dock at Galveston, Texas

Texas Gulf Sulphur Co.

75 East 45th Street, New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas

Development:

Iron Ore In Peru

Utah Construction Co., of San Francisco and a Peruvian Government corporation have signed an agreement for development of a large iron orebody in Peru. Most tests show 60 pct iron or better. Most of the ore is magnetite.

Although ore will be shipped mainly to Eastern U. S. blast furnaces, shipments to the West Coast may develop as the orebody opens up. The construction firm indicated three American steel companies have shown interest in the project.

The orebody is located 300 miles south of Lima and about 15 miles from the coast at the same longitude as New York City. Allen D. Christensen, executive vice-president of Utah Construction noted that the distance is shorter between Peru and the East Coast.

The ore deposit measures about four to five miles in one direction and 10 miles in the other. As many as 15 outcroppings within these limits have been reported. Several of the outcroppings are thousands of feet long by several hundred feet wide, Christensen said.

Shipments between 100,000 and 200,000 tons of ore per month are projected by the company. Cost of opening the mine to production may go over $5 million, Christensen said. It would include building of docks for ocean going vessels, housing, and heavy duty mining and processing equipment.

The contract with the Peruvian government gives Utah Construction six to eight months for additional tests and a 20 year concession for mining the orebody. Peru will collect royalties on all ore. The company will also supply about 300,000 tons per year for an electric furnace to be installed by the Peruvian Government at Chimbote. No steel is produced in Peru now.

Utah Construction formed the Argonaut Mining Co. last year, and was shipping iron ore from British Columbia to Japan at a rate of more than 50,000 tons a month, before winter weather decreased operations.

Inco Sets Record

International Nickel Co. of Canada mined a record 7.78 million tons of ore in 1951, setting a mark unequaled in the firm's history, according to John F. Thompson, chairman and president.

"The company operated at a maximum capacity in 1951," Thompson said, noting that 2 million more tons were mined than in 1950. Total ore mined from both underground and surface operations was 11.8 million tons compared with 9.84 million tons in 1950.

Emergency equipment installed several months ahead of schedule brought the company's rate of nickel production to 21 million lb per month, a 5 pct increase over the rate prevailing about mid-year. Company officials predicted that the firm will be able to hoist 13 million tons of ore a year by the end of 1953, when production from surface operations will be fully replaced. If reached, the goal will be twice as much from underground as in any year before 1951.

Chile Copper Pact

Chile is reported to be asking more money for its copper, and unless the increase is forthcoming, may renounce an agreement with United States companies under which most of the metal is mined in that country.

According to the contract, Chile is allowed to export to world markets about 20 pct of the annual 400,000 tons mined annually. World market prices are higher than the 27½ cents per pound copper brings in the United States. Behind the action is said to be the decline in the price on the world market and competition from the same companies operating the mines in Chile. The world market price is about 50 cents.

Meanwhile the Government was also reported negotiating with the International Materials Conference for an increase of 6 cents per pound on the price of copper exported to the United States. Chile would then renounce its agreement concerning the 20 pct for export, in the face of an assured 33½ cents per pound. Sources said Chile will levy a 6 cent per pound export tax on the metal if the increase is not granted.

Other sources said the increase is being asked for in the form of a compensation for turning over the export quota to U. S. firms. Almost a year ago an agreement was reached whereby Chile would receive 27½ cents per pound for copper sold here. The price was 3 cents more than that established for domestic production by the Office of Price Stabilization.

One source said American companies are selling copper in bars at $600 a ton, against Chile's asking price of $1,200 on the world market.

Ore Bonus Increases Uranium Production

The Atomic Energy Commission incentive bonus plan appears to have given United States uranium production a shot in the arm since its establishment in June 1951.

About one-third of the 70 mines certified for bonus payments showed no production before the March 1, 1951, retroactive date. More than $250,000 was paid out since the publication of *Domestic Uranium Program Circular 6*. The bonus is paid to new producers and certain existing producers on any part of the first 10,000 pounds of uranium oxide delivered to qualified mills and ore stations between March 1,

Jamaican Bauxite

First alumina calcining kiln erected on its foundations at the Jamaican Bauxites, Ltd.'s new plant, now under construction in Jamaica. This is the first alumina producer in the Caribbean.

"FREE AIR" IMPACT

This method of size reduction has definite advantages when crushing certain hard and soft ores, chemicals and mineral rock. Note how the material in the Impactor illustration above drops through the centrally-located feed chute, penetrates deep into the path of the oncoming beaters and is sharply struck — the shattered particles being driven against massive sidewall anvils where they receive a second shattering. They rebound into the beater circle and are again struck by the rotating hammers, continuing to shatter under the high velocity, repeated impact-rebound action until they are swept out the open bottom of the Impactor. The result — less fines — a cubical shaped product — and since there is no attrition, power and maintenance costs are minimum. Also, Impact crushing acts along natural cleavage lines — freeing foreign material from ores and preparing it for more efficient cleaning.

PENNSYLVANIA CRUSHER COMPANY
1728 Liberty Trust Building, Philadelphia 7, Pa.

Division of Bath Iron Works Corporation

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1951, and February 28, 1954. The bonus is paid directly to producers, in addition to the established prices paid by processing plants and purchasing stations. Payments have been made to 61 properties to date, and have resulted in sizable income increases to many small operators.

By the end of 1951 about 190 applications for certification of mining properties for the bonus were received by the Colorado Raw Materials Office at Grand Junction. More than one-third of the applications have been acted upon. Others are being processed. The bonus is separate from the $10,000 premium announced in 1948 for discovery and production of high-grade uranium ores from new domestic deposits. No one has qualified for the earlier bonus.

Winter Dumping Solved

A lacework of strip heaters installed under the floor of 60-ton, bottom dump ore-transfer cars is being used to keep the ore from freezing and sticking to the interior of the cars during winter months.

Manufactured by Atlas Car Co., the cars are used to fill the bins on blast furnace high lines. Generally loaded by buckets, the operation takes long enough for freezing to make dumping difficult. Before the introduction of strip heaters, burning coke was placed in the bottom of the hopper before loading.

The heaters are clamped directly to the hopper plates in a way which allows expansion and contraction and ease of individual replacement. Direct clamping allows for the transfer of a maximum amount of heat by conduction to the hopper plates. They are also enclosed in insulated steel cabinets to prevent heat loss.

Western Mineral Development

Westvaco Chemical Div. of Food Machinery & Chemical Corp., announced the formation of a Mineral Development Dept. at Pocatello, Idaho, under the management of O. A. Power, former manager of the J. R. Simplot Fertilizer Co.

With Power will be H. B. Fowler, Ace Allen, and W. C. Peters, geologists, and E. L. Spencer and W. A. Young, mining engineers. Westvaco Div. operates barite, magnesite, and dolomite properties in California and Nevada. It also has a $15 million project under construction at Westvaco, Wyo. for development of the trona deposit there. The company uses large tonnages of phosphate shale from the Fort Hall deposits in its expanding phosphorus production near Pocatello, Idaho.

W. B. Thom, president of Westvaco, says the company intends to develop further the many mineral resources of the West.

Record-Breaking Coal Production in Britain

British coal mines produced a record-breaking 532,000 tons above a similar period one year ago, in the first six weeks of 1952. Despite advances all along the line, however, Britain is not producing the coal she needs for her expanding industries and the needs of allies on the continent.

The British information Service says the heavy expenditure on colliery development planned for the next 15 years by the Coal Board will be needed to prevent decline in output, rather than add to present production. Coal is now being mined in deep pits with narrow veins.

The manpower situation has improved, with a rise to 705,300 from the 696,500 men in the mines a year ago, and shifts per miner have risen. Overall output per manshift is up by 21 pct since 1945, to an all-time high of 1.21 tons. Coal exports are running 30 pct higher than in 1951 and time lost by strikes is less than half of the loss before the war.

The installation of certain types of American cutter-loaders has increased output, but most new machines must be adapted for British use. British consumption has increased from an average 178 million tons a year in the five years before the last war to 208 million tons in 1951. Expansion of industry and the arms program has accounted for the increase. Home coal consumption has been cut 30 pct under that of prewar days.

Miners are the highest paid industrial workers in Britain, but the long-term downward trend in manpower was only recently arrested. Miners' families, the usual source of replacement, are smaller now, and job opportunities away from the mines are more plentiful. Because of lack of compulsory direction of labor in Britain, no worker can be ordered to take a job and stay on it. Thus, the use of foreign labor is a problem. Whether foreign workers should be accepted into a particular pit rests with the miners' lodge at the pit.

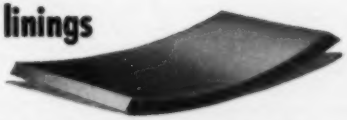
The National Coal Board plans to spend £520 million during the next 15 years and the Government is expected to mitigate the flow of funds. Material priority will also be supplied where possible.

Anaconda to Supply Uranium

The Atomic Energy Commission has contracted to buy uranium produced at an ore-processing plant that the Anaconda Copper Mining Co. will build near Grants, N. Mex.

A purchasing station for uranium-bearing ores has been established on the Navajo Indian Reservation at Shiprock in extreme northwest New Mexico. Grants is in West Central New Mexico.

Lengthen the life of your mill linings with



U·S·S LORAIN ROLLED PLATE LINERS...

YOU get the full life of your mill lining when you install U·S·S Lorain Rolled Plate Liners. They're so rugged that they remain serviceable until worn paper thin. And because plates of reduced thickness can be used, you increase the usable diameter of your mill, boost the output.

U·S·S Lorain Rolled Plate Linings are made to accurate size and in easy-to-handle sections,. . . save hours of installation time and greatly reduce mill down-time. Economy in maintaining both shell and linings is assured when you install these tough, long-lasting linings. Close fits between liner plates and between the liner plates and lift bars eliminate shell wash and allied troubles. And because plates are made interchangeable, severe localized wear at feed or discharge ends may be balanced by shifting the plates . . . restoring grinding efficiency at only partial lining cost.

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U·S·S LORAIN ROLLED PLATE LININGS AND U·S·S GRINDING BALLS

USS

UNITED STATES STEEL

MIXED emotions were produced by the announcement that the buildup of weapons will be stretched out till mid-1954 instead of the previous 1953 deadline. Reason: government assistance programs will be tougher to get but there will be easement in materials allocations.

Earlier in February, DPA had announced that tightening up on regulations governing rapid tax amortization would become effective March 1. In the future, DPA will have to certify amortization contracts for all construction and permanent installations costing more than $100,000. This action was necessary according to DPA's James F. King, so that new industrial expansions already approved could be assessed in the light of the changing critical mineral picture. When DMPA inherited the backlog of government assistance requests from DMA, it moved in fast. The results of DMPA's work is described in the article on p. 351 by James K. Richardson. The speed with which these requests were approved and the lengthening of the military program have made a reappraisal of the critical mineral list necessary.

It looks as though the consumer industries will be getting more metal soon and, led by steel, there is an industry push toward the abandonment of CMP. Relaxing of materials controls appears imminent but discontinuing CMP is in the "let's talk this thing over" stage.

AT least one iron ore operator is feeling the repercussions of the wage negotiations in steel. Labor spokesmen in this case are playing for time so that they will have the benefit of any increases in steel workers' wages and prices as a bargaining point.

The situation in steel focuses attention on the basic weaknesses of a government-controlled economy. Steel prices are controlled and so are wages. But the Wage Stabilization Board finds that the 20¢ per hour increase in wages demanded by the union technically conforms with existing stabilization rules. The Office of Economic Stabilization is willing to go along with a $3 per ton price increase but the industry claims this figure must be in the $6 to $9 range to enable it to grant the 20¢ wage increase. Since the steel industry will accept the wage boost if a commensurate increase in price is permitted by OES, any strike that occurs is a strike for higher prices.

The present situation has a precedent. In 1946 the nation was immobilized by strikes in nearly every major unionized industry. Steel held out for price increases from OPA which it was successful in getting only after plants had been closed and pressure to resume production had become insuperable.

Whatever the outcome, it will influence wage negotiations in the mining industry as contracts expire. Since some increase in price and wages will be agreed upon under any circumstances, the government will have lost a battle in its war against inflation.

WHEN Manly Fleischmann made it known that DPA was entertaining an offer from Aluminum Company of Canada to export 3½ billion lb of aluminum to the United States, he was met by a storm of protest from aluminum producers. The proposal provided that if the Canadian company could not find commercial buyers for the expected exports in the amount of 300,000 short tons a year during the contract years, the United States would, if requested, purchase an amount not to exceed 180,000 tons annually for stockpile purposes. The prevailing market price at the time of delivery would be paid.

While DPA is receiving comments on this offer from industry—mostly of the "is this step necessary" variety—at the back of the agency mind is the narrow margin of electric power reserve in the U. S. A stockpile of aluminum pigs, is a stockpile of electric power. Future wars will be decided on air power, and aluminum in quantity is essential to airplanes. In 1939 with no aluminum stockpile existing, the nation met the emergency with an electric power plant reserve of over 35 pct which permitted the necessary expansion of aluminum reduction plants. An effort is being made now to get electric power plants up to 15 pct reserve capacity.

Another facet to the power situation is that a large segment of the aluminum industry is concentrated in the Northwest and uses power generated by hydroelectric plants. A poor year in rainfall can and has curtailed aluminum production. Because of these factors, DPA would like to have an aluminum stockpile of about 4 million tons. Acceptance or rejection of the ALCAN proposition may depend on whether industry can supply the stockpile in addition to present commitments.

ONE good thing which has come out of the engineering shortage is the present preoccupation of corporate management with its relations with engineering personnel. As a result, the National Society of Professional Engineers organized the Professional Engineers Conference Board for Industry composed of industrial executives. The Conference Board polled 100 top industrial executives to determine what studies should be conducted in order to relieve the present shortage of engineers and improve engineering-management relations. Industrial management, in response to the poll, came up with these topics:

How to improve engineering-management communications

How to improve the utilization of engineering manpower

How to attract qualified engineers

How to train engineers in industry

When the Conference Board sounded the nation's top industrial management, it found out that the lack of communications between management and engineers was depriving industry of at least 60 pct of its potential managerial talent possessed by the engineers.

Findings of the survey are presented in an attractive 46 page booklet, done in two colors. The report sums up the survey findings with a review of new techniques and the latest research on improving group communications, and suggests a detailed formula for improvement in engineering-management communications. The chief engineer is the key

man in management-engineering employee communication. Indeed, he determines the extent to which engineers participate in company planning.

Although a large majority of companies want the opinions and suggestions of their engineers on company policies, it was found that there is only minor participation in planning by the majority of engineers. Also, 63 pct of the companies surveyed provided no special publications or communication channels for engineers, although 88 pct of firms want their opinions and suggestions. In all companies, personal discussion between engineers and immediate supervisors is the predominant method of communicating company policies and informing engineers of company plans. The line of supervision is adhered to in this practice, with each level passing information down to the next. Seldom do company top executives speak and write directly to the engineering staff.

Asked for opinions on how to improve communications, industrial executives replied that participation by top management in communications with engineers should be broadened. The majority opinion was that top management meeting with engineers would stimulate them to apply their analytical talents to over-all company success.

The booklet, which can definitely be used as a work book, describes an "engineering audit" plan which individual companies can apply to determine how effective their communications with engineers are.

The audit is recommended as a first step in finding out what engineers want to know about their company and how management can tell its story most effectively. The audit will find the basis for a communications policy which can use a variety of communications techniques. The next step of the formula is a plan for the review and test for effectiveness of methods and media, using the audit findings as a guide. Up-to-date techniques in the conduct of conferences, meetings, and seminars are presented.

The third step suggested by the report is the designation of a single top management man to be responsible for effective engineering-management communications. It is suggested that the top engineering executive should have this responsibility because he has the greatest stake in the improved productivity of his engineers.

THE Neely coal mine inspection bill, as reported by the Senate Labor and Public Welfare Committee, is in the form of an amendment to the 1941 Federal Coal Mine Inspection Act. The amendment authorizes the Secretary of Interior to:

▼ Establish safety standards and requirements to be observed in the operation of coal mines.

▼ Order coal mine inspectors to withdraw miners from coal mines where an imminent danger exists.

By the terms of the amendment, violators of a regulation on which they have been warned must pay a fine of $2000 or six months in jail, or both; and $10,000 or two years, or both, for violation of a withdrawal order. While complying with closing orders, the operator may appeal through the Dept. of Interior but not directly to the courts. The bill spelled out certain conditions on which minimum safety standard should be specified and provided that state safety laws would be superseded except where they were in direct conflict with the bill.

Commenting on the bill the Committee did not consider that it constituted an unlawful delegation of legislative power. The Civil Aeronautics Board and the Coast Guard were cited as examples of agencies with delegated power to prescribe and enforce regulations in accordance with law—not power to make laws. The Committee did not recommend enacting the Safety Code into law as it would be ill-adapted to changing conditions.

A companion bill, HR-268, is under consideration in the House. Estimated cost of administering an inspection act would be about $6 million annually.

AN expansion goal for zinc has been set by DPA deputy administrator Ralph Trigg at 1,320,000 short tons in the form of metal and zinc in salts and pigments. This is 230,000 tons over the 1950 supply. New facilities will account for 190,000 tons of the increase and the remaining 40,000 will come from increased production from existing sources. Although 178,000 tons which are to come from new facilities have been certified by DPA for government assistance, not much relief for civilian consumers is seen until 1953.

IN answer to the cry from the coal industry for more engineers, the National Coal Association formed the Vocational and Education Committee about two years ago to encourage young men to take courses in mining engineering. Representatives of the industry serve on the committee which functions through meetings at the various colleges which have coal mining engineering curricula. At these meetings, the committee has an opportunity to tell students of the career opportunities open to them in the coal industry. A by-product of these meetings has been the opportunity for faculty men to keep curricula up-to-date with the needs of the industry by advice from the industry representatives. To date meetings have been held at Ohio State, West Virginia University, University of Illinois, Missouri School of Mines and Metallurgy, Colorado School of Mines, and Lafayette College.

THE Malayan tin producing industry, hammered from pillar to post by the Japanese during the last war, faced with destroyed or heavily damaged equipment, and more recently plagued by communist sabotage and terrorism, is making a strong comeback. In spite of the obstacles encountered Malayan tin production has climbed to more than 57,000 tons a year. In line with advancing production, Malayan tin producers have established the Malayan Tin Bureau in Washington, D. C., to provide information to users in the United States. Lynn W. Meekins is the director and has a long career in United States foreign trade promotion. He returns in December from a visit to Malayan tin-producing areas. The establishment of the information center is perhaps one of the strongest reflections of the importance of the world's largest tin producer to the world's largest tin user. It should prove extremely important as a measure of the world market pulse relative to the metal.

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¾"	1.050	0.824	350	0.140	400 ft. coils
1"	1.310	1.070	200	0.181	300 ft. coils
1¼"	1.660	1.380	200	0.267	300 ft. coils
1½"	1.900	1.610	200	0.320	250 ft. coils
2"	2.378	2.070	170	0.445	200 ft. coils
2½"	2.875	2.469	170	0.680	200 ft. coils
3"	3.504	3.070	163	0.910	100 ft. coils
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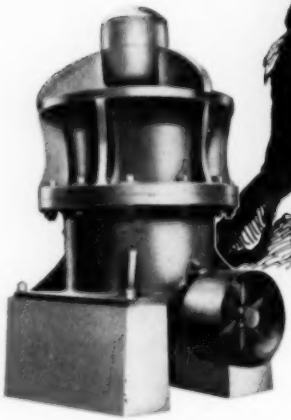

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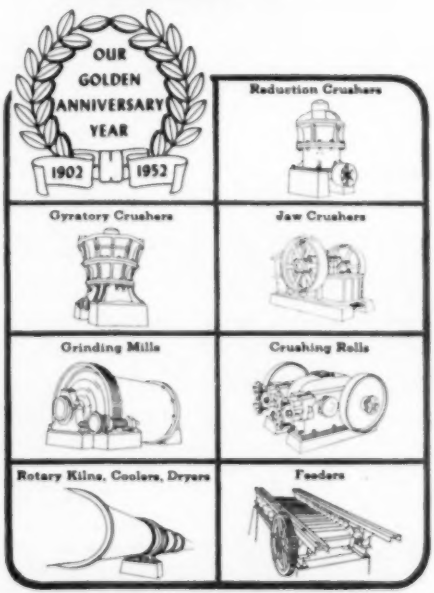

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MINING
ENGINEERING

EDITORIAL

WHAT PRICE SECURITY

AN unprecedented expansion of the mineral industries began in mid-1950. There are few minerals on the strategic list for which some source of supply here at home has not been found. All types of inducements have been utilized, ranging from RFC loans to guaranteed-price purchase contracts. No one can deny that tremendous progress toward mineral self-sufficiency has been made. Despite the greatness of these accomplishments, made in the name of national defense, one cannot help but have a feeling of uneasiness over the price which has been paid—in indebtedness, in freedom, and in the sacrifice of private enterprise.

The people of the Soviet have been enslaved by a military state which attempts complete control of the economy. A similar yoke has been imposed on the business life of this nation. Of course, there is a difference in degree of control and in purpose. We are dedicated toward defense and the resistance of aggression. And, our personal liberties have not been usurped.

The realization of the extent to which this nation has been forced by Communist aggression to adopt the practices of the socialized state is appalling.

Even though we must be sympathetic to the problems of the executive branch of the Government, we cannot help but be critical of some of the methods employed. On the one hand it refers to depletion allowances on mineral properties as "loopholes," while on the other, the industry receives public money in exploration subsidies. Every effort is made to squeeze the last possible cent in taxes to support the defense effort, and then these monies are returned to the industry in subsidies in the name of defense. In addition, they are squandered in the establishment of a multiplicity of agencies to oversee the dispensing of public funds.

Would it not be far better and cheaper to modify tax laws to encourage the exploration for minerals? With the shining example of Canadian tax laws for mining ventures so close at hand, there seems little excuse for the short sightedness in this respect. Possibly our own eagerness to accept the Government assistance programs is partly to blame. While extolling the virtues of free enterprise, we lobby for subsidies, tariffs, and other means of government assistance. A picture of inconsistency is presented by an industry which requests tax relief at the same time asking for government financial assistance.

Unfortunately the mining industry does not muster as much popular support—votes to be specific—as does the farm industry. This makes it difficult in normal times to influence Congress for proper mineral legislation. But, in a national emergency, the importance of minerals is manifest. This is the time for our leaders, whose advice is sought by the Government, to press home those measures which would create a climate in which the industry can flourish without truckling to politicians for Government hand outs.

The methods by which we achieve national security are as important as the security itself. Our miracle of production for defense may turn into a quagmire from which we can only escape by jettisoning the ways of life we are striving to preserve.

You're headed for efficient mine ventilation with

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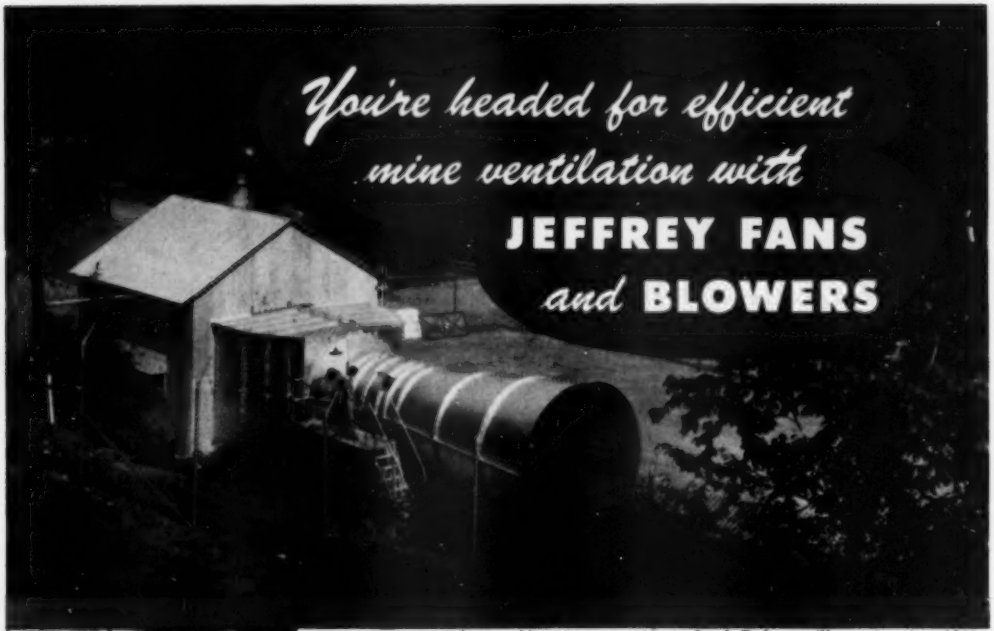

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Ease of blade adjustment is one of the important features of the Jeffrey Aerodyne Fan. The rotor assembly provides 12 blades designed for individual adjustment. Positive, accurate adjustment is made by removing one set screw in each blade, rotating the blade to desired position and resetting the set screw.

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Military preparedness coupled with maintaining the civilian economy at existing levels has created a demand for mine products far beyond peacetime needs. The major portion of this expansion has been within the concepts of the free enterprise system. A degree of government participation has been necessary as it is the only body remotely able to estimate ultimate industrial and military needs. The assurances, purchases, and promises of government have created ore which earlier was waste, fashioning entirely new concepts of mineral economics. This program has resulted in...

Unprecedented Expansion In The Mining Industry

by James K. Richardson

FIRST indications that mineral industries expansion is beginning to show results are contained in the report by Defense Mobilizer Charles E. Wilson, *The Battle for Production*. The report, submitted to the President early this year, says that the United States has reached a $2 billion-per-month rate in military deliveries—three times that of 1950. Plant expansion in 1951 totalled $11.1 billion, the report states. Certificates of accelerated amortization have been approved to cover $11.4 billion in proposed plant construction. In reference to plant expansion significant to the mineral industry, the report states:

- Steel industry goal is 120 million ingot tons by 1954, compared with present 108 million ingot ton capacity.
- Taconite beneficiation should result in 15 million tons by 1955.
- An existing annual aluminum output rate of 860,000 tons.
- An estimated 500,000 tons of sulphur by late 1953.
- Manganese production up 50,000 tons as the result of new projects in 1952.
- Montana tungsten project coming into production in 1952.
- Present zinc production expansion projects to add an estimated 150,000 tons to the 1951 production figure in 1953.

Information gathered from official sources, other than Mr. Wilson's report, indicates an increase in the annual capacity of other segments of the industry by 1955, as shown in Table I.

MR. RICHARDSON is Assistant to the General Manager, Utah Copper Div., Kennecott Copper Corp., Salt Lake City, Utah, and an AIME Member.

Table I. Increased Annual Capacity of Certain Metals Anticipated by 1955

Commodity	Amount of Increase	Commodity	Amount of Increase
Copper	225,000 tons	Cobalt	2,100 tons
Lead	36,000 tons	Nickel	18,000 tons
Zinc	230,000 tons	Chromium (45 pct ore)	50,000 tons
Cadmium	1,300 tons	Fluorspar	64,000 tons
Magnesium	54,000 tons	Fluxstone	3,700,000 tons
Aluminum	620,000 tons	Magnesite	73,000 tons
Titanium	4,300 tons	Mica (hand cobbied)	5,000 tons
Molybdenum	31,000,000 pounds	Sulphur	180,000 tons
Tungsten	600,000 units	Borax	380,000 tons
Manganese (45 pct ore)	150,000 tons	Soda ash (natural)	300,000 tons

For mine and refinery expansion, U. S. Potash is spending $4.5 million at the Carlsbad, N. Mex. plant. The expansion is expected to produce 250,000 tons of 60 pct K_2O.

Other expansion plans are being made in potash, phosphates, uranium, antimony, tin, beryllium, garnet, graphite, columbite, etc. Domestic deposits will contribute the major portion of this potential production increase. However, foreign sources will supply some measure of the gains.

How much is the expansion program going to cost? Conservative estimates, based on application for certificates of accelerated amortization, fix the cost at more than $2 billion. A partial breakdown among major segments of the industry would be about as follows:

Table II. Estimated Cost of Expansion Program

Commodity	Dollars
Iron and taconites	385 million
Copper and molybdenum	250 million
Lead and zinc	150 million
Light metals	620 million
Other metal and nonmetallics	130 million
Total	1735 million

Defense Minerals Exploration Administration approved contracts have resulted in an increase in the mineral potential of the United States. Some consider the projects ill-advised. DMEA, however, attempts to protect public funds by requiring private participation on a matching basis. According to the last report, 218 exploration contracts were executed at a total cost of approximately $11 million. Government's share was about 58 pct. Average total cost per approved project was $55,045. The greater part of the explorations involved nonferrous proposals, but the scope of the search is all-inclusive. A list of minerals sought in 24 states and Alaska reads like the Periodic Table.

The Government has recently made an excursion into the twilight zone of mineral subsidies for specific copper producers, after confining itself mainly to the areas of accelerated tax amortization, guaranteed market contracts, direct or guaranteed loans, and exploration assistance. A brief summary of some of the major jobs is indicative of what is contemplated or now under way in the United States minerals field.

Table III. DMEA Contracts Executed Through Jan. 31, 1952 by States

State	Government Participation	Value of Contract	Number of Contracts
Alaska	$295,675.50	$358,234.00	3
Arizona	314,275.00	529,459.00	7
Arkansas	54,684.75	72,913.00	4
California	801,341.13	1,140,292.50	13
Colorado	731,455.78	1,248,759.00	31
Georgia	7,312.00	8,124.00	2
Idaho	969,731.00	1,809,713.00	25
Iowa	7,425.00	14,850.00	1
Michigan	284,096.50	568,193.00	1
Missouri	316,512.67	480,409.19	4
Montana	501,540.40	964,620.91	26
Nevada	236,205.79	418,601.59	11
New Mexico	196,200.50	392,401.00	2
North Carolina	113,027.40	125,586.00	25
Oklahoma	78,000.00	156,000.00	1
Oregon	56,390.25	85,187.00	3
South Carolina	4,581.00	5,090.00	1
South Dakota	172,740.60	191,934.00	8
Tennessee	6,768.00	7,520.00	1
Texas	113,602.00	184,029.00	3
Utah	1,005,252.46	1,902,968.68	18
Vermont	124,421.00	161,062.00	3
Washington	345,753.25	435,586.50	13
Wisconsin	128,025.66	265,762.75	10
Wyoming	89,280.00	178,560.00	2
	$6,946,298.21	$11,705,876.12*	218

* $18,353.28 was spent on contracts terminated through Jan. 31, 1952.

IRON

Most major iron ore developments seem to have taken place outside of the United States. However, the Reserve Mining Co. has awarded construction contracts for a 2½ million annual ton commercial taconite plant, using 24 pct feed. The project includes a 47-mile railroad, power plant and vessel loading docks at a cost of more than $105 million. Two taconite pilot plants in the Lake Superior district are scheduled to go into operation this year at an estimated cost of about $40 million. An ultimate goal of 15 million tons annually of taconite may cost the industry $500 million.

Extensive work is in progress in the Lake Superior

Table IV. DMEA Contracts Executed Through Jan. 31, 1952 by Commodities

Commodity	Government Participation	Value of Contract	Number of Contracts
Antimony	$106,044.75	$221,393.00	7
Asbestos	357,812.10	397,569.00	6
Beryl-Mica	85,093.60	94,548.00	8
Cobalt-Nickel	402,689.07	534,452.39	4
Copper	680,988.19	1,361,979.39	16
Fluorspar	3,896.50	7,793.00	1
Lead-Zinc	3,196,515.24	4,406,741.91	72
Lead-Zinc-Cadmium	12,000.00	24,000.00	1
Lead-Zinc-Copper	931,897.85	1,863,795.70	21
Manganese	147,451.50	196,602.00	5
Mercury	334,841.25	446,455.00	7
Mica	79,446.50	88,275.00	25
Monazite	12,648.00	14,052.00	1
Steatite Talc	29,267.10	32,519.00	1
Sulphur	138,119.50	276,239.00	3
Thorium	9,183.50	10,215.00	1
Tin	144,000.00	160,000.00	2
Tungsten	989,695.48	1,319,593.97	30
Uranium	224,688.08	249,653.42	7
Contracts Executed	$6,946,298.21	$11,705,876.78	218
Cancellations (no money spent)	185,487.50	316,933.00	9
	$6,760,810.71	$11,388,943.78	209
Terminations	43,649.40*	56,218.00	8
Active Contracts	$6,717,161.31	$11,332,725.78	201

* $18,353.28 was spent on contracts terminated through Jan. 31, 1952.

region. Although no important new ranges have been discovered, extensions of known orebodies have been located and accelerated stripping programs begun. Because of these operations and recent underground developments, an anticipated 100 million gross tons is expected before substantial tonnages are received from newly developed foreign sources.

MANGANESE

In the past, the United States produced only about 10 pct of its manganese requirements, despite using the major portion of the world's supply. Anaconda, producers of 95 pct of our domestic production, is making every effort to increase its output. Completion of the mill at the Three Kids deposits in Nevada should add to 1952 production. Work continues on the low grade deposits of the Cuyuna range, Minn., and at Artillery Peak, Ariz.

Work experiments on the vast low grade deposits at Chamberlain, S. Dak., is being carried on by the Bureau of Mines and a number of steel companies.

Extensive research, involving private and public funds, is being conducted to recover manganese from open hearth and Bessemer slags. Several processes have been devised but none have proved economically practical.

COPPER

Anaconda's Greater Butte project has been watched with great interest for several years by the entire mining industry. An estimated 6000 tons of low grade ore per day is anticipated during the first year as a result of the development. An eventual output of 15,000 tons per day is expected in the second year.

Beginning in 1954, Kennecott's Deap Ruth project, at Ruth, Nev., abandoned earlier as marginal and now designed to block cave low grade copper ore, will produce an additional 8000 tons of low grade ore per day. Construction on this project, estimated to cost approximately $14 million is in progress.

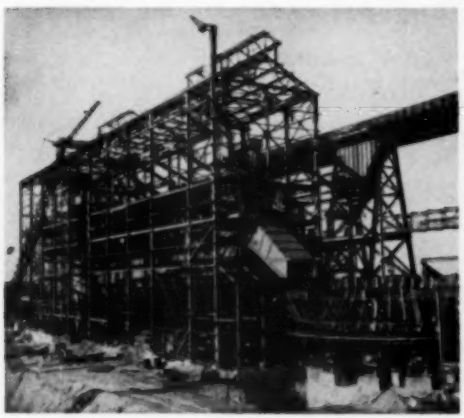
Some of the DMPA's more significant copper purchase contracts are:

▼ Anaconda's Yerington mine in Lyon County, Nev. involves an investment of $32.75 million and is expected to bring 30,000 tons of new copper to the domestic market. The anticipated life of the property at this rate of production is 10½ years. Contract has been let for construction of 225 houses. Construction of the leaching plant will start soon and is scheduled for completion in 1953.

▼ Copper Cities' orebody development near Miami, Ariz. will cost the company about $15 million, and is expected to result in the output of 22,500 tons of copper annually, beginning in October 1954.

▼ The expansion of Phelps Dodge's Bisbee east orebody, the Lavender pit, is expected to cost about $25

Part of the Oliver's $20,000,000 program of research and development on Mesabi taconite and low-grade ores, this 1,000,000-ton capacity experimental plant is expected to provide answers to some perplexing taconite production problems. When in operation, the plant will utilize a 350-foot nodulizing kiln and a 96-foot sinter bed to agglomerate fine iron ore particles into larger lumps which can be used in blast furnaces.



million. The annual production is expected to reach 38,000 tons of copper with production starting late in 1954 or early 1955. Stripping and development work are well advanced.

▼ Stripping has started on American Smelting & Refining Co.'s Arizona Silver Bell property. AS&R plans on spending approximately $17 million and hopes to reach an annual production of 18,000 tons of copper by 1954.

The recent announcement of approval by RFC of a loan of approximately $57 million to Copper Range for opening of the White Pine property is of national significance. It opens up the tremendous copper potentials of northern Michigan. Construction is expected to start this spring and approximately 25,000 tons of copper will be produced annually in about three years. No purchase contract has been announced as yet by DMPA.

San Manuel, with an estimated $10 million already spent on their Arizona property, is still awaiting Government action on a loan and purchase contract. Shaft work, preliminary underground development, and experimental caving and drainage work within the orebody is continuing.

LEAD and ZINC

An additional 18,000 tons of zinc per year is expected from two new zinc fuming plants (Herculaneum and Selby) by 1953.

Among new properties now coming into expanded production are Calumet and Hecla at Shullsburg, Wis., where production started in 1951 and anticipates an annual production of 15 to 18,000 tons of zinc; and Pend Oreille at Metalline Falls, Wash., which expects to produce approximately 18,000 tons of zinc during 1952.

Other important projects for new or expanded zinc production and the additional tonnages anticipated in 1953 are:

▼ 13,000 additional tons from St. Joseph Lead's Balmat, N. Y., property, and 9000 additional tons from Indian Creek and adjacent Missouri properties.

▼ Universal Exploration anticipates 9000 additional tons from Jefferson City, Tenn.

▼ AS&R expects to get 10,000 additional tons from its Van Stone, Wash. property.

Ore loss through the exhaustion of the Franklin ore deposit will be largely replaced by planned production increases for New Jersey Zinc at Ogdensburg, N. J.; Friedensville, Pa.; Colorado, and Virginia.

Little plant expansion is planned for lead. Except for the Herculaneum project of St. Joseph Lead, expected to increase lead production 35,000 tons a year by 1954, newly mined lead will come mainly from expanded and new operations, mining complex lead-zinc ores.

ALUMINUM and MAGNESIUM

Additional alumina will come from a new plant being built by Alcoa at Bauxite, Ark. The plant will have a rated capacity of 400,000 tons of alumina a year.

Alcoa is expanding its capacity by 205,000 tons of aluminum by the erection of new producing plants in Wenatchee, Wash.; Rockdale, Texas; and the extension of its Point Comfort, Texas, plant. Kaiser is enlarging its capacity by 220,000 tons with a new plant near New Orleans and an addition to its Spokane plant.

Reynolds hopes to expand its capacity by 120,000 tons with a new plant at Corpus Christi, and by enlarging its plants at Troutvale, Long View, and Jones Mills.

While aluminum capacity will have increased 80 pct over pre-Korea output, the activation of six government-owned World War II plants will increase magnesium production 800 pct over the same base period. Five companies have executed management contracts with GSA. The output of these plants is expected to be diverted exclusively to military use or the stockpile. Total production is expected to rise from the 16,000 tons in 1950 to 122,000 tons.

TITANIUM

Titanium Metals Corp. of America, jointly owned by National Lead and Allegheny Ludlum, is producing sponge titanium at Henderson, Nev. The intense interest in this field, particularly by major chemical and paint companies, coupled with expansion of existing production, will undoubtedly lead to an over-all expanded domestic capacity.

PHOSPHATES

New expansion in phosphates involve investments of more than $25 million. The largest expansion is that of International Minerals & Chemical, near Bartow, Fla., estimated to cost approximately $10 million. It is designed to produce coarse phosphate products and by-product uranium. Coronet Phosphate is expanding its Tenoroc mine and constructing a fluorine recovery plant which will open the way to an important new source of hydrofluoric acid. American Cyanamid is investing approximately $2½ million to expand its Brewster, Fla., plant and Saddle Creek mine. The company anticipates a 500,000-ton increase in local capacity. Major expansions in this industry will be completed this year.

POTASH

The potash industry plans to spend about $28 million in new developments near Carlsbad, N. Mex. Southwest Potash is putting $10 million into its new mine and refinery, giving it a capacity of 185,000 tons per year of K_2O. Duvall Sulphur & Potash is spending $8 million for construction of a new mine and refinery which started production in 1951. It is expected to produce 250,000 tons of 60 pct K_2O. U. S. Potash is spending about $4½ million for mine and refinery expansion. International Minerals & Chemical is investing a similar sum in mine expansion and in a plant to recover magnesium oxide and other chemicals.

COBALT

Calera Mining is currently shipping to its new smelter at Garfield, Utah. The Salt Lake refinery is expected to be in operation early in 1952 using the new Chemical Construction process. Metal production is estimated at 4000 tons of copper and 3.3 million lb of cobalt per year.

National Lead is spending $5 million to recover cobalt at its Fredericktown, Mo., mine and St. Louis refinery. It too, will use the new CHEMCO process, treating 50 tons of concentrates per day. DMPA announced that it expects to obtain 7 million lb of cobalt, 9 million lb of nickel, and 3500 tons of copper from this project during the next five years, although completion is not expected until spring, 1953.

MOLYBDENUM

Climax Molybdenum is making a substantial addition to its molybdenum and tungsten capacity. The

Truck haulage plays important role in the production of uranium on the Colorado plateau. New discoveries and plant facilities will be responsible for the increased production of this vital commodity, and many major companies are showing interest in uranium.

government has announced clearance of an amortization certificate for $9.27 million.

SULPHUR

At least four new sulphur deposits will be in production by the end of 1953, meaning an additional one million long tons of capacity. Three of the new deposits are in Louisiana—Starks dome near Lake Charles is already in production; Bay St. Elaine dome, southwest of New Orleans, is due to be completed this year, and Garden Island Bay dome, near the mouth of the Mississippi, is scheduled for operation in 1953. The other new deposit is at Spindletop dome, near Beaumont, Texas, and is due to start work in 1952.

Garden Island Bay is the largest of the projects and has a 500,000 ton per year objective. Plans call for the construction of a $10 to $15 million plant.

Nineteen other projects in the United States for obtaining sulphur from natural gas, petroleum, refinery gas, smelter gas, pyrites, and surface deposits are being carried out.

URANIUM

Uranium production figures are unobtainable, but progress has been gratifying. The AEC recently announced that the United States ranks second among uranium-producing countries. Representative Gore stated that uranium supplies have increased to the point where the United States could double its atomic energy program.

U. S. Vanadium and the Vanadium Corp. of America continue to lead in the development of new sources in the Colorado plateau area, but significantly, many major companies are showing interest in uranium. Climax, united with Minerals Engineering, is exploring the plateau, and operates the Grand Junction uranium recovery plant. Anaconda is carrying on geological studies, drilling, and underground development in Utah and north of Grants, N. Mex. Indications are that they will construct one or more treatment plants. Anaconda technique should be one of the greatest assets in the uranium program. AT&SF Railroad is doing an outstanding job with development of deposits near Grants, and is reported to have found some of the best uranium orebodies discovered in the United States. They have acquired 44 claims in the Marysville, Utah area, and have indicated work will begin this year.

TUNGSTEN

While its own ore output is limited pending completion of an underground shaft, U. S. Vanadium at Pine Creek, Calif., is adding to the artificial scheelite capacity of its digestion plant, and milling a large amount of custom ore. Nevada-Massachusetts and Getchell Mines are opening new ore deposits giving promise of equalling their World War II production. Wah Chang plans mills at the Old Lincoln mine at Tempinte, Nev., and the Black Rock mine north of Bishop. Construction, soon to be completed by Tungsten Mining, is expected to nearly double its output. The U. S. Tungsten Mines operation in Fresno County, Calif., will begin construction of a 100-ton mill this spring.

Wilson's reference to a Montana tungsten source unquestionably applies to the Brown's Lake deposit. It's a low grade deposit of powellite with scheelite. Tentative plans call for a large tonnage rougher concentrator on Union Pacific Railroad and a chemical plant at Butte, presumably to make synthetic scheelite. Minerals Engineering and the newly formed American Alloy Metals are the largest operators in the area.

MERCURY

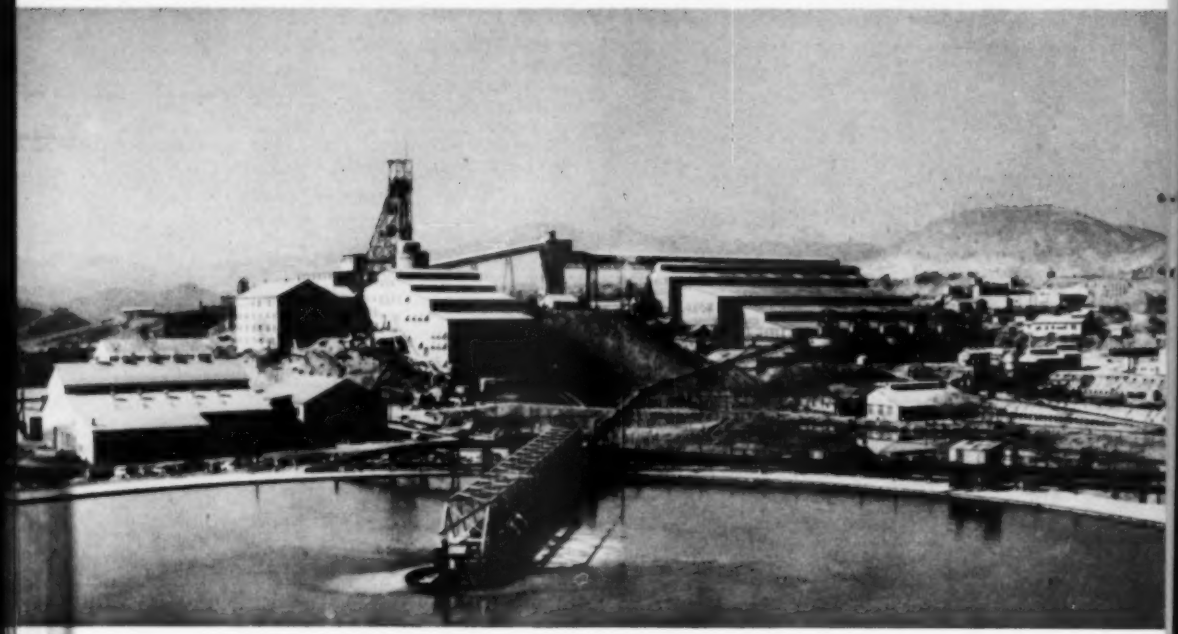
The mercury price has not been conducive to the search for new orebodies. It is reported five or six fair sized quicksilver producers will soon be in production, as compared with two in 1949. These additions to mercury production will be Cordero Mining in Nevada, the new Idria mine, and the Reed mine of Bradley Mining.

CHROME

The chrome picture is far from good. Investigations of recovery of chrome and other minerals from Oregon beach sands continue with some success, but no large plant is now in sight. An application has been made for Government financing or guarantees to permit reactivating the chrome properties in Montana, prepared for large scale production by Anaconda during World War II.

This brief summary of major domestic projects in no way attempts to cover the entire field. It is merely indicative of the steps that are being taken to improve the national position in the minerals field.

Little assurance is given that these presently contemplated projects and the official production estimates based upon them will meet ultimate needs. In the field of copper, alone, it has been stated that work toward development has started in virtually each of the known deposits. If this is true and estimates still are below anticipated demand, it would indicate the need of bold and aggressive steps in the development of exploratory and production techniques currently beyond the scope of thinking in the industry. Apparently the mineral industry is at the same productivity point which faced the oil industry some years ago upon the near exhaustion of the apparent, shallow structures. The employment of similar daring and imaginative methods, equipment, and techniques seems indicated on mining's part if the nation is to maintain its industrial prominence in the fabrication and production of metal materials.



Production at the Miami mine of the Miami Copper Co., is approximately 13,000 tons per day of one pct copper ore. In the foreground is the thickener tank and the headframe and mill are on the hill above.

Electrical Installations at the Miami Mine

by C. A. Ross and B. R. Coil

NEW demands for underground power in the Miami mine of the Miami Copper Co., Miami, Ariz. has brought about expansion of the distribution system for both ac and dc power. Progress in mining equipment and the normal changes in the mine were responsible for this increased demand.

Early power requirements were for pumping and haulage. A 440 v ac power line down No. 5 shaft took care of a small pumping load and shaft station lighting, 275 v dc power was generated by motor generator sets on the surface, with a churn drill hole from surface to the 570 haulage level serving as a cableway. Electric lights were installed where power was available, and thus were confined to the haulage level and shaft stations. All industrial power in the Miami area is 25-cycle, which dates back to the hydroelectric generator installation at Roosevelt Dam in 1908-10.

The Problem

The main haulage level was moved to the 720 level and later, to the 1000 level, requiring a longer feeder line with the resultant voltage drop. Also, as mining progressed to the east, the churn drill hole for the power cable would have been subjected to subsidence cracks.

MR. ROSS and MR. COIL are Underground Electrical Foreman, and Assistant General Manager, respectively, Miami Copper Co., Miami, Ariz.

The first extension in the use of electricity was in electric blasting. About 1935 the mine went to electric blasting, using the dc haulage current. Bringing electric current to the working levels of the mine for blasting greatly expanded the use of electric lights. Lights were used in tool rooms, powder and cap magazines, stairways, and other semi-permanent installations.

Like all mines, Miami Copper began to study and experiment with mechanical mucking and transportation of ore by slushers, shakers, and belts during the late 1930's and early 1940's. At the beginning of the program, power was supplied from the haulage level 275 v dc system. Later it became necessary to run a cable, carrying 440 v ac power, down the No. 7 ventilation shaft.

The increased use of power came about gradually, and many new problems were added, not the least being the introduction of switch boards and power cables into the working areas of the mine, where drifts and crosscuts take weight, and require repairs.

The 25-cycle current presented special problems, in that 25-cycle transformers are twice as large and about 2½ times as heavy as 60-cycle transformers of the same power output. The 25-cycle transformers were considered too large for installation in the mining areas.

In 1947 the distribution system was revised and standards were adopted, governed by the following

Typical slusher drift, showing 25 hp slusher installed. The slusher hoist transfers ore from the chute raises to the haulage cars.

Switching-station vault for one operating stope. Power for fourteen slusher hoists is supplied from one station.

Are Cheaper With Flexible Cable

factors: 1—Safety and protection for the operating personnel; 2—Control of stray currents for the protection of electric blasting; 3—Prevention of electrical failures, and particularly electrical fires; 4—Flexibility of installations to permit timber repairs; 5—Standardization of equipment and installations.

Present Distribution System

Power enters the mine at three locations. Two 350,000 cir mils—3 conductor, lead-covered, steel armored cables through No. 5 shaft supply 440 v, 3 phase, 25-cycle current for the pumping loads on the various levels, and for shaft station lighting. The pumping stations have 710 hp, handling mine drainage and copper-bearing water from leaching of worked-out areas. The No. 7 ventilation shaft carries 440 v, 3 phase power to operate the slusher hoists and belt conveyors in an isolated section of the mine. The cable in the shaft and distribution system will be removed when mining is completed in those areas.

The main power supply is brought into the mine through a 10 in. cased churn drill hole at 6900 v, 3 phase, 25-cycle, by a 2/0—3 conductor, lead-covered, No. 6 spiral armored cable, banded for vertical suspension. This cable terminates in a substation on the 1000 level.

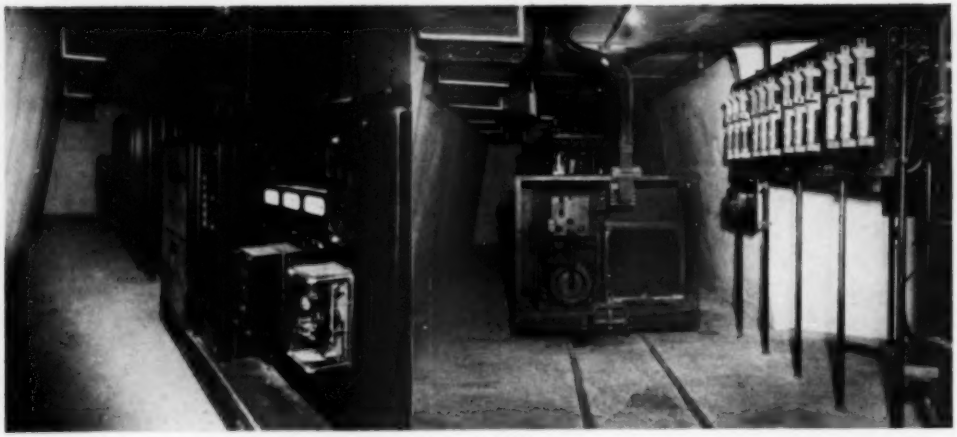
The 1000 level substation is a drift 65 ft long, the last 35 ft being 9 ft wide, and the first part, 17 ft wide. The drift is timbered with 10x10-in. posts and 8-in. H-beam caps, and side and back lagging are covered with ¾-in. transite. The floor is concrete. The station is closed with screen and a locked door, and is unattended, except for inspection and maintenance. A 10 hp blower with filtered intake supplies 12,000 cu ft per min for ventilation.

Located in the substation, is a bank of transformers to supply 440 v ac current for mining, and an Ignitron rectifier set to supply dc current for the haulage system.

Alternating Current Supply

The transformer bank, consisting of 3—250 kva inerteen insulated, self-cooled, Westinghouse transformers, connected delta-delta, supplies ac power through four circuits to the mechanical stopes. Primary voltage is 6900 v, 3 phase, 25-cycle, and the secondary is 440 v, 3 phase, 25-cycle.

Main power cables to the stopes are 4/0, 3 conductor, lead-covered, No. 6 spiral armored, and an attempt is made to take these cables to the mining areas through drifts in good ground. Detours of considerable length are made to avoid heavy ground. Main power cables terminate in copper bus bars mounted in a 30x30x8-in. junction box, with a rain-shed cover. The junction boxes, together with switch boxes are mounted on panels in a switching station. If possible, the switching station is placed in a stub drift excavated for this purpose. The stub drift is 6 ft wide x 7 ft high x 12 ft deep. Factors



considered in selecting a location for a switching station are: 1—Must be close to the stope to be served (150 ft or less); 2—Should be in the best ground possible to eliminate repairs; 3—Should be dry if possible.

From the switching station, for each slusher in the stope, a magnetic contactor control circuit of 600-v, neoprene cable is run to the starter switch. From the magnetic contactor-switch unit, at the switching station, a 6-conductor cable is connected to each slusher motor. This cable is a standard neoprene 600-v cable containing 3 insulated conductors and 3 bare wires. The uninsulated wires are for grounding the equipment and furnishing protection to the men working around cables.

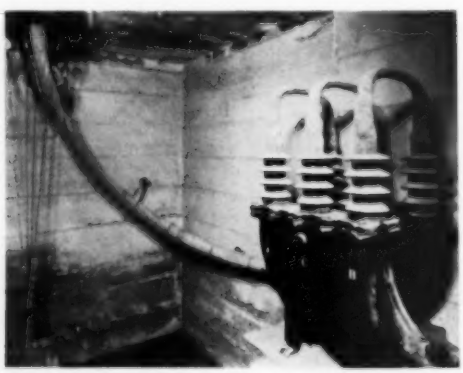
The following is a list of the electrical equipment installed in the average stope:

14 — 25 hp slushers.
14 — 100 amp, 3 pole, 600-v switches and magnetic contactors.
2 — standard junction boxes.
2 — 440 to 110 v dry type transformers.
2500 ft — 3-conductor No. 6 power cable.
2000 ft — 4/0 3-conductor lead-covered standard armored cable.
4000 ft — No. 12 3-conductor and 4 conductor type S cable.
8000 ft — No. 12 2-conductor cable.
14 — outlet boxes, caps, and cables for electric blasting.

The average stope is wired in approximately 40 man-shifts, as contrasted with 100 man-shifts required before standardization and the use of flexible power cables.

First class workmanship is required on all electrical installations. The possibility of stray currents and the use of ground wires are studied before the installations, and carefully checked after completion of work.

The average stope requires a large bundle of cables in the stope fringe drift from the switch panel to the operating area. In some stopes, this fringe drift is heavy and requires constant repairs, particularly during the early stages of drawing ore from the stope. The cables are tied with twine every 3 or 4 ft to form a flexible bundle, and the bundle in turn is hung from the caps by twine hangars, with large loops to allow slack. This enables the timberman to move and protect the bundle of cables when making timber repairs. If the fringe drift is in good rock, the cables are supported by steel hangars fastened on the drift posts. All cables are inspected regularly for squeeze and strain.



Main power supply enters mine through 10-in. churn-drill hole. Above, bottom of drill hole showing 6900 v cable coming into the main transformer vault.

Direct Current Supply

Direct current for the trolley haulage system is supplied by a Westinghouse Ignitron set, Type ISDO6, rated at 300 kw at 275 v dc. The Ignitron is designed for mine service and is mounted on three mine cars, the ac switching gear car, the transformer car, and the dc rectifier car. The main transformer is 365 kva inerteen insulated, self-cooled and operates on 6900 v ac, 3 phase current.

The cooling system for the rectifier tubes employs a water-to-air type heat exchanger with maximum coolant temperatures of 25°C. The rectifier tube frames, tubes, and cooling system are at full potential above ground. The tube cathodes form the trolley potential of the 275-v dc circuit.

The Haulage System

Ore is hauled from transfer raises in trains of 25 to 35 gable-bottom, side dump cars of 86 cu ft ca-

Above, supply drift with bundle of flexible cable hung on the timber. Cable can be moved readily for any timber repair.
At right, stope switching station in heavy ground. Repairs are costly and difficult in these areas.

pacity. These trains are hauled by two 6-ton trolley locomotives, each powered by two 30 hp, 230 v traction motors. The rated draw-bar pull per motor is 3000 lb and the rated speed is 6.5 mph. All motors are equipped for tandem operation at either end, or for use as single motors. In switching and supply service, they are used as single motors, while in ore service they are operated in tandem, both locomotives being operated from the lead locomotive.

The haulage track is 24-in. gage and 45-lb rail, with the exception of the main haulageways where 70-lb rails are used because of heavy traffic over this section. The grade is 0.3 pct in favor of the load, and all traffic moves in one direction, with loops at the dump pocket and in the working area of the mine. Curves have a radius of 41 ft, and all switches are ground-throw spring switches, with manganese cast frogs.

The power distribution system for haulage is divided into 3 circuits, the main line of each carries a 500,000 cir mils bare feeder cable mounted above the trolley with a combination feeder and trolley clamp. Trolley is 4/0 figure eight, and is carried on rigid suspension construction by rain-shed type hangars and trolley clamps attached to the caps. Trolley clearance from the rail is maintained at 7 ft 2 in. Careful grading and proper tension have extended the main line trolley life to 80,000 trains or 18 to 20 months.

On main lines a 500,000 cir mils ground feeder is carried near the bottom of the drift posts, and every six rail lengths, this feeder is tapped to the bonded rail circuit. This low resistance negative circuit reduces stray currents to a minimum, as a protection for electric blasting.

Trolley pole actuated switches are used to automatically set up block signals, and to open and close water sprays for spraying the tops of loaded cars. The hand-throw track switches actuate electric switches, which light red or green lights to indicate the direction the switch is set. Hand pull switches are used to set block signals at cross-overs and other places on the main line, and hand pull switches are used with signal lights for spotting cars under the chutes.

The trolley is installed as a complete network, and any section or drift may be de-energized by trolley switches, for timber repairs or chute blasting.

Telephones

Coordination between the haulage level and the ore drawing in the stopes depends on a network of telephones and, in some cases, additional communication is provided by signal lights. There are more than 70 telephones underground on 10 lines to the surface exchange and 20 local lines. Most of the telephones are hooked to two circuits, the circuit being selected by a hand-throw switch.

Electrical Crew

The underground electrical crew consists of 9 men per 24 hr day and a foreman. These men install, salvage and reinstall all electrical equipment in the mine, to meet the demands of the mining program. Probably the most important job of the electrical crew is a constant preventive maintenance program, covering all wiring, motor installations, haulage motors, and telephones. This program not only prevents loss of tonnage due to breakdown, but prevents fires and blasting accidents.

The Miami mine is one of the major copper producers of the Southwest, mining an ore body of cupriferous pyrite coated by chalcocite, occurring in seams and uniformly disseminated through altered pre-Cambrian schist and granite. Production of the less than 1 pct copper ore is about 13,000 tons per day. The thoroughly fractured, silicified schist is suited for the block caving method used in mining.

The ore production is hoisted through the No. 5 shaft, which also serves for lowering and hoisting men and supplies. The other three shafts, No. 4, No. 6, and No. 7 are ventilation shafts and serve as emergency exits. The underground operating crew averages 425 men per day.

Manganese: Sources and Beneficiation

RUSSIA was the United States' Number One source of manganese ore in 1948 when 34 pct of imports were received from that source, stated Norwood B. Melcher, assistant chief, ferrous metals and alloys branch, Bureau of Mines. In 1949, this country received only 20 pct of 1948 shipments from Russia, and only token amounts are now being received. Aggressive programming by industry and government resulted in prompt increases in shipments from major producing sources; India, Gold Coast, and the Union of South Africa all increased exports to fill the vacuum left by Russia and provided an excess adequate to increase total imports approximately 290,000 short tons in 1949. Again in 1950, and with even less ore from Russia, imports increased another 290,000 short tons. Since the shift from Russia as a source of manganese, the United States has received in total about 85 pct of its imports from India, Union of South Africa, Gold Coast, and Brazil in that order of importance.

Producers of both home-consumed and merchant ferromanganese have been able to adjust downward the manganese content of the home-consumed product and so obtain partial relief. Millions of tons of steel were produced in 1951 with a relatively low grade ferromanganese. This adjustment has been made without decreasing the quality of the steel, although with some increase in cost through introduction of new problems, including increased handling of material and additional removal of carbon.

Forced into a pattern of price and grade structure such as exists today, the producer of ferromanganese must adopt one of three possible courses as a short-range program: 1—He may continue to deplete his stocks by producing standard (78 pct) ferromanganese and hope that the future will bring some form of relief; 2—he may attempt to produce 78 pct ferromanganese by paying higher prices for premium ores; or 3—he may drop the grade of ferromanganese and stretch stocks and future supplies of ore as far as possible.

The present rundown condition of Indian railroads is attributed to the fact that the service has had no opportunity to recuperate since the beginning of World War II, while the demand for the movement of commodities has probably increased.

The Union of South Africa has expanded its exports to the United States greatly since 1948, but the showing of that country in 1951 was disappointing. Efforts have been made for some time by firms in the United States, at the urging of the manganese miners in the Union, to prevail on the railroad authority to grant and make available larger allocations of cars for manganese ore movement. As a whole, such efforts have been unsuccessful. Although the allocation of rail shipping has been the obvious factor in the decreased movement of ore, many other less determinate factors appear to be involved.

Brazil, long an important supplier of manganese to the United States, has important manganese deposits in three areas, all of which are significant to this country.

The Gold Coast is an important source of supply. Its metallurgical ore is particularly of significance because of its unusually high grade which permits considerable latitude in blending with the lower grade materials of South Africa and India.

The Belgian Congo should have an output of 100,000 tons or more annually beginning this year.

R. S. Dean presented two papers. One with K. M. Leute on hydrometallurgical methods for recovery of manganese from domestic ores and one as sole author on the so-called *carbamate* or Dean process. The two papers tied into each other. In the first mentioned he reviewed the various processes applicable to oxidized, and nonoxidized and reduced ores. The advantages of each were pointed out.

So far the only process tried on a substantial scale on oxidized ores was the SO_2 process used at Las Vegas, Nev., on Three Kids ore during World War II. Many problems were encountered. Some of them were whipped while some of those remaining perhaps would have been whipped had time permitted. Since then work has been done elsewhere to avoid the formation of the troublesome thionates encountered at the Three Kids plant. Dean discussed the thionate and NO_2 processes as applied to oxidized ores.

The only commercially used process on reduced ores is that of making electrolytic manganese. Among others that have been considered are the nitric acid process, the Bradley-Fitch ammonium sulphate process, and Dean's ammonium carbamate process.

Dean's thesis was that extremely large tonnages of so-called low grade manganese ores are available, and that these should not be depleted in attempting to simulate a foreign metallurgical grade ore. He pointed out that the grade of the domestic manganese ores would be considered high if the same grade were found in copper ores. The selling price of electrolytic manganese and electrolytic copper are roughly the same.

In addition to electrolytic manganese, he believes that domestic ores should be used to make exceptionally high grade products. These might be battery grade oxide or substantially pure oxide sinter, which might be used for high manganese alloys or for upgrading metallurgical grade manganese to produce a high manganese ferroalloy.

The carbamate process is based on the fact that manganous oxide is readily soluble in concentrated ammonia solutions containing ammonium salts. In solutions of sufficiently high concentration the manganese exists as an anion. Lixiviants of ammonia and ammonium carbonate permit extraction of the manganese from reduced ores and the manganese can be recovered as carbonate by heating or by driving off ammonia.

R. V. Lundquist presented a paper on upgrading high-silica ores or concentrates with sodium hydroxide to extract silica and to yield a product with a more favorable manganese : silica ratio. The NaOH is regenerated in part by CaO.

This timely session held on Tuesday morning, Feb. 19, 1952 at the AIME Annual Meeting was sponsored jointly by the Extractive Metallurgy Div. and the Minerals Beneficiation Div. J. H. Jacobs, U. S. Bureau of Mines, Boulder City, Nev., and John D. Sullivan, Battelle Memorial Institute, Columbus, were Associate Chairmen.

Taconites *beyond* Taconites

by N. M. Levine

WHETHER the United States and its allies can meet the challenge of a war brought by the Communists will depend largely on who wins the battle of steel production. At the present stage of the world situation, the United States and the other members of the Western family of nations have the lead on iron curtain countries. But we have no sure way of knowing what is happening at Magnetogorsk and other Russian iron and steel producing centers.

We must also face the possibility that we may have to meet the challenge alone. The fortunes of war and world politics can strip us of friends and co-fighters quickly. The destruction of Hiroshima and Nagasaki are indicative of what the world can expect if war-madness ever grasps the earth again.

Our domestic supply of high grade open-pit and underground iron ore is dwindling because of the drain of three wars and higher than ever civilian consumption. The production of iron ore and its eventual use in blast furnaces are the critical problems of an armed democracy today. The world crisis has led to efforts towards beneficiation for increasing ore supplies. The huge reserves represented by the magnetic taconites at the eastern end of the Mesabi, once in production, should provide us with a substantial portion of our native ore for many years.

The estimated 10 to 20 million tons of concentrates annually can be increased in an emergency. If we had a certainty of peace for the next 50 to 100 years, the situation would be a stable, hopeful one, aided by importations of high grade ore from sources such as Canada and Venezuela. The hard truth is that we have little surety of peace tomorrow morning.

Let us assume the U. S. could build sufficient processing plants for increasing production of magnetic taconites under the pressure of national emergency. We must also recognize the power of atomic warfare to contaminate an area as large as the Eastern Mesabi. Thus, it becomes imperative to seek some means of protecting our ability to produce the steel we may one day need to survive.

The nonmagnetic taconites, completely dwarfing the magnetic taconites areawise as well as tonnagewise, might provide us with this insurance. Present indications are that they will be considerably more expensive to treat, but in a desperate situation we might be very grateful for ores yielding 40 to 50 pct Fe recoveries at grades of 53 to 58 pct Fe carrying low phosphorus.

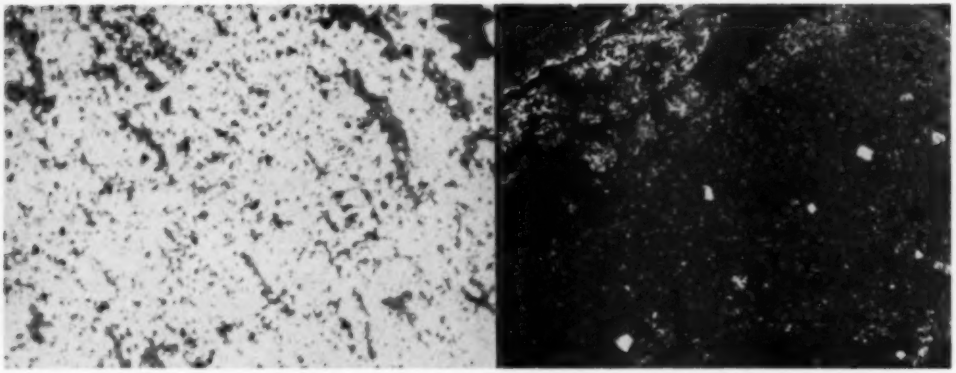
MR. LEVINE is with the Mineral Engineering Dept. of the Columbia University, New York.

The University of Wisconsin, because of the difficult iron ore situation in the state, has been working on the nonmagnetic taconite problem for the past three years in the hope of making a contribution toward its eventual solution. In Wisconsin, the Western Gogebic Range has been the state's most effective iron producing area. Today however, only two mines are in operation, both underground and approaching depths of more than 3000 ft. The range, however, does have a large supply of nonmagnetic taconites and presents a promising field for study. While the Gogebic offers one large source of nonmagnetic taconites, Michigan and Minnesota have even greater supplies of such material. Alabama, the northeastern states and the West all have low grade iron ore sources which might be utilized under extreme conditions.

The Gogebic Range located in northeastern Wisconsin and northwestern Michigan has a total length of about 70 miles, about 45 of which are in Wisconsin. The iron formation averages 500 to 600 ft in width, dips 70° to the north and strikes at approximately N 63° E. The formation is sedimentary and consists of six distinct members characterized by alternating divisions of ferruginous chert and ferruginous slate. The footwall is generally quartzitic and the hanging wall of a sideritic slatey character.

The iron minerals are mainly hematites with some magnetites, goethites, limonites and small amounts of siderite. In the area studied, very small amounts of iron silicates were observed. The magnetites occurred mostly in the Anvil-Pabst and Pence members, mixed with hematites and representing roughly about 10 to 20 pct of the total iron in the formation, thereby characterizing it as nonmagnetic. The gangue is of various forms of silica such as chert, opal and flint. Complete liberation of iron and gangue minerals is rare. There is always some iron present in the chert ranging from jasper-like solutions to fairly coarse iron oxide specks. Likewise, one always finds finely dispersed silica within the iron minerals.

In late 1943 the Bureau of Mines carried out a trenching and sampling program in the two mile stretch between Iron Belt and Pence in Iron County, Wis. Preliminary work was based on samples from one of the four trenches cut by the Bureau of Mines. More detailed work following the preliminary analysis was then undertaken on samples composited from all the trenches, thereby giving a wider and more representative coverage of the area. A study of the



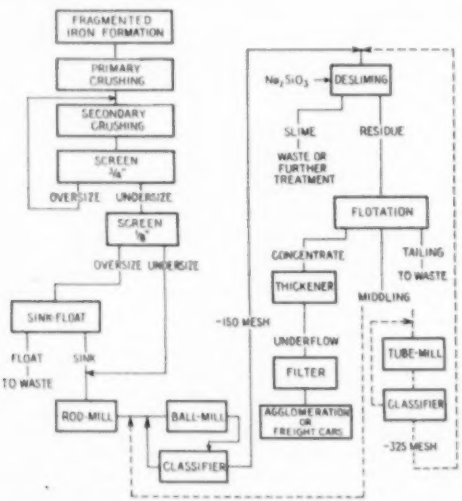
Beneficiation of the non-magnetic taconites requires fine grinding to liberate the hematite particles. The photomicrograph to the right shows the degree of dissemination; hematite particles (white) in chert (gray). To the left is polished section of the Plymouth formation; finely disseminated chert (dark gray) inclusions in a hematite (white) and magnetite (light gray) intergrowth. Magnification 150X.

geology of the area indicates uniformity in the members to considerable depth.

The preliminary work consisted of a breakdown of the samples from each of the individual divisions (Plymouth, Yale, Norrie, Pence and Anvil-Pabst) by means of heavy liquids and screens. Iron analyses and iron distributions were obtained. In addition polished sections, thin sections, crushed fragment, and liberation studies were made. From this preliminary study the following tentative conclusions were derived:

1—A high degree of variability in mineral hardness, texture, size and dissemination of minerals characterizes the ore.

2—The more cherty members (Plymouth, Norrie and Anvil-Pabst) appeared to be amenable to heavy media coarse gangue rejection, while the slatey members did not.



Beneficiation plants with this flowsheet may be someday the backbone of the domestic iron ore supply; based on methods now available this process would produce a suitable blast furnace feed with Fe recoveries of 40 to 50 pct.

3—Liberation of iron and gangue minerals was progressive with decrease in size.

4—Extremely fine ultimate grind would be required to obtain the highest degree of liberation.

5—Substantial portion of the iron lost in sink-float was too fine to be recovered by beneficiation short of leaching.

Preliminary analysis pointed to an attack based on the principle of alternating stages of size reduction with stages of concentration, in order to reduce the total amount of material ultimately to be ground to minus 325 mesh and then concentrated at this fine size in order to obtain maximum recovery.

The program consisted of the following essential parts which finally led to the tentative metallurgical flowsheet shown under Fig. 1.

1. Heavy-media or sink-float testing of $-\frac{3}{4}$ in. $+8$ mesh feeds for rejection of gangue employing a 20 in. American Cyanamid cone with a ferrosilicon medium.

2. a) Humphrey Spiral and table testing on intermediate sized feeds (-8 mesh $+65$ mesh).

b) Hydraulic classification-sizing studies on intermediate sized feeds designed to show the feasibility of gravity concentration in the intermediate size range.

3. Desliming of -150 mesh ground sink product.

4. Cationic and anionic flotation of gangue using feeds of deslimed ground sink product. Circulating loads of 250 pct were used in the grinding of the flotation feeds in order to minimize slime and approach more realistic liberation of the minerals.

The results of heavy-media testing, based upon bulk formation feeds, are not as good as those on the cherty feeds. However, from the standpoint of the economics of bulk mining vs selective mining, they appear to be as good. On the Gogebic Range, because of the 70° dip, the obstacles to cheap selective mining are formidable.

The problem of gravity concentration in the intermediate size range was examined by hydraulic classification-screening studies which permitted a more detailed and controlled analysis of the problem.

Exploration of the anionic gangue flotation problem employed sodium oleate as the collector, Ca^{++} to activate the siliceous gangue, and investigated various combinations of pH, oil-soap collectors, iron oxide depressants, reagents to remove iron oxide

coatings from the gangue surfaces. Also, resurfacing with sodium silicate was tried.

A study of the effect of particle size on the cationic flotation of the gangue indicated the need for a size reduction to 100 to 150 mesh to get the particles to float. Best results were obtained with the following scheme: 1—Desliming with Sodium Silicate; 2—Collection with lauryl amine hydrochloride added in stages of 0.08 lb per ton; 3—Optimum pH range between 7.8 and 8.2; 4—Depression of iron oxides with caustic starch.

Photomicrographs of tailing, middling and concentrate products indicated that grinding of middlings to −325 mesh would liberate considerably more iron and gangue minerals.

The data revealed that the concentrate could not be increased much above 57 to 58 pct Fe without suffering a large decrease in recovery. In order to yield a silicon content of about 10 pct it would be necessary to raise the concentrate grade to above 60 pct Fe. The silica content of the 57 to 58 pct Fe product runs 13 to 14 pct, which is just out of the range of blast furnace requirements unless mixed with richer ores. It is not beyond the realm of possibility, however, that blast furnaces may some day have to modify their requirements in the direction of higher silica contents.

Overall recoveries, including losses in sink-float and desliming, are 41 to 49 pct. While these are not as satisfactory in comparison with the magnetic taconites and other sources, can we afford to ignore these ores completely in view of a possible national emergency? Furthermore, there are avenues still open for improving the above recoveries.

Selective flocculation of slimes after desliming, if successfully achieved, could increase iron recoveries appreciably. Small scale batch tests performed indicated the nature of the desliming problem. The slime is essentially non-selective and carries with it from 9 to 13 pct of the iron in the feed, depending on the total weight of slime.

The second avenue open for raising recovery is the regrind. This must be explored as part of a continuous testing program to really yield effective information. It would not be unreasonable to hope for a 25 to 50 pct recovery or better of the middling iron, quite a boost to the process as a whole.

Basing the calculation of the overall ratio of concentration on a 30 pct Fe feed and the data on sink-float, desliming and float tests, ratios of 4.6 and 3.6 are indicated. Thus, in addition to potentially higher costs and poorer grades than the magnetic taconites are expected to yield, the ratios of concentration are also above the 3:1 predicted for them. However, in an emergency we might find ourselves only too pleased to have such sources at our disposal.

Who knows, perhaps some day the question of treating the *taconites* beyond the *taconites* may not appear as far removed as it does today.

Books for Engineers

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten per cent discount given whenever possible. Order Government publications direct from the agency concerned.

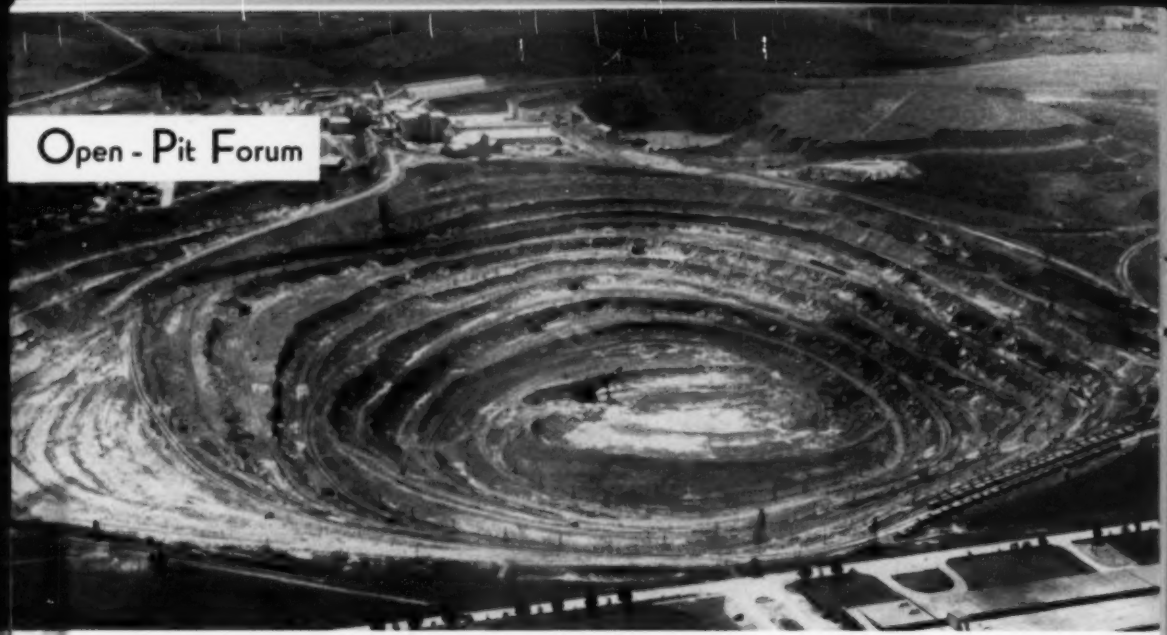
Manufacturing Processes. By Myron L. Begeman. Published by John Wiley & Sons. Third Edition, 608, $6.—The Third Edition is written primarily for students and professionals engaged in production, industrial, or tool engineering work. It gives the reader detailed information on all the important manufacturing processes and machines now available—where they can best be applied, their advantages and drawbacks, the tools required for each machine, etc. The first half of the book is devoted to foundry practice, pattern work, plastic molding, powder metallurgy, hot and cold working of metals, heat treatment and welding. The second half covers measuring instruments, cutting tools, machines, and their accessories.

Soil Engineering. By Merlin Grant Spangler. International Textbook Co., 1951, 458 p., diag., tables, charts, cloth, $6.50.—Written for the beginner in the field, this book should be useful to undergraduate students and to practicing engineers who have not had formal training in soils. Some of the chapters are on the nature of soil, structure and texture, density, water in soils, engineering soil classification, stability of slopes, embankments, earth dams, pressure on retaining walls, piles, and under ground conduits.

Energy Sources—The Wealth of the Worlds. By Eugene Ayres and C. A. Scarlott. Published by McGraw-Hill. 344, $5.—How long will existing fuel supplies last, and what can we do against the day they are exhausted? Here is an analysis of this vital problem—a thorough census of our energy sources, past, present, and future—technically sound, yet at the same time making fascinating reading, particularly for all with any interest in science and technology. The history of man's efforts to wrest energy from nature is given, then a detailed review of the size of energy resources, technology of production, efficiency of conversion, and progress being made in conservation. With only the statistics not readily accessible elsewhere, the book interestingly depicts much about all types of energy sources and what we may expect of them in the future. Oil, coal, hydro-electricity, solar and nuclear energy, even wind and tide power and others, are covered.

Modern American Engineers. By Edna Yost. Published by J. B. Lippincott Co. 182, $2.50.—Here are the stories of a dozen men who have achieved signal success, including among others: Robert E. Doherty of Carnegie Institute of Technology, Pittsburgh; Vannevar Bush of Carnegie Institution, Washington; Ole Singstad, Engineer of the Holland Tunnel; and U. S. Senator Ralph Flanders of Vermont. Each story gives the boyhood education of the man, his professional training and path to success, how he chose his specialty and his current achievements. The high school boy or girl, or the college student attracted to engineering as a career will find inspiration and guidance in this book.

Elements of Ceramics. By F. H. Norton. Addison-Wesley Press, Inc., 246 p., illus., charts, and tables, cloth. $6.50.—Intended both as a college text and a reference work for craftsmen, this book covers the broad principles of ceramics based on an approach from crystal physics and unit processes. Beginning with the composition, structure, and properties of both clay and nonclay minerals, the book continues with the topics of plasticity, forming methods, kilns, glazes, enamels, coloring and other decorative processes.



Combined rail and truck haulage are used to transport ore and waste from the open pit of the Asbestos, P. Q. operation of the Canadian Johns-Manville Co., Ltd. The picture is a general view of the surface plant at the Jeffrey mine.

Rail and Truck Haulage At Canadian Asbestos Open-Pit

by K. V. Lindell

THE 70-mile serpentine belt of eastern Quebec, producing 70 pct of the world's chrysotile, has 11 operating mines, two of which are underground, eight are open-pit, and one is both open-pit and underground. The combined operation, the Jeffrey mine, of the Canadian Johns-Manville Co., Ltd. is the largest producer in the group.

Haulage

All four of the separate operations falling under transportation at the Johns-Manville Jeffery Mine at Asbestos, P. Q., is handled by the company owned Asbestos and Danville Railway. A variety of equipment is operated over the 25 miles standard gage railway. Included in the scope of transportation are:

1—Hauling mill rock to the mill.

2—Hauling stripping and waste rock to the waste dump.

3—Hauling mill tailings to the tailings dump.

4—Hauling supplies from, and finished products to Danville.

Main line tracks are permanent, but those within the pit and on the dumps have to be relocated constantly to follow the mining face and dump edges. Tracks within rock areas in the mine are laid on steel ties and can be moved by a bulldozer. Standard mechanical track shifters move tracks in dirt areas in the mine and on the dumps.

Train-movements, both within the mine and over the out-lying tracks are controlled by a dispatcher located at the southwest rim of the pit. Steam locomotives haul all stripping, waste rock, and ore from the mine to the gathering yard at the northwest rim of the pit.

Normally, two trains per operating shovel are used, with adjustment for optimum loading. In the event of shovel loading on the bottom level or in good stripping, service may be increased to three or four trains per shovel.

From the gathering yard a 100 ton diesel-electric locomotive hauls the mill rock to the mill slips, a distance of about three miles. Electric or steam locomotives haul the waste rock and stripping to the waste dump located about two and one-half miles from the mine.

Stripping cars are sprayed with a chloride solution and "gravelled" to prevent wet stripping from freezing in the cars during the cold months. Cars pass under a shaking screen which distributes an even

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Large haulage units are used in the asbestos industry; shown is a loaded 25-ton Mack truck climbing the haulage road from the pit.

layer of dry mill tailings over the bottom of each car, providing an insulating layer between the wet stripping and metal car bottoms.

The A&D railway also handles all freight between the Jeffrey mine and the Danville interchange yard of the C. N. R., an average haul of about four miles. Combined incoming and outgoing freight handled in 1950 totaled more than 500,000 tons. A 100 ton diesel-electric unit does all the A&D freight work.

All railway and mine equipment is serviced in either the machine shop or the roundhouse. Maintenance includes complete overhauls on shovels, locomotives, and cars. A mobile repair crew, equipped with tools, welding and cutting torches, handles minor shovel repairs in the pit. The repair truck has been modified to run on rails. For heavier jobs, boom changes on shovels for example, the railroad's crane is available.

A small gasoline-driven car distributes drill rods, bits, explosives, and general supplies to the mine. The car is especially designed for its task and makes scheduled trips between the machine shop, storehouse, cobbing shed, and various mine levels.

The mine supervisory staff and shovel operators keep close check on all broken ore faces and ore during loading operations. Barren rock is either cast aside, temporarily by-passed, or loaded into waste cars by shovel operators. Each ore car is classified separately as excellent, good, medium, or poor mill rock. The car number and grading are recorded on both mine and mill slips, providing a cross check. The bore hole and level from which the rock is mined are also recorded for monthly checking against borehole data.

Loading is carried out by four 4-cu yd, one 5-cu yd, and one 8-cu yd electric shovels loading directly into cars. Three shovels maintain production. The total of six shovels are needed to keep desired selectivity and minimize shovel movement.

Two ¼ cu yd gasoline power shovels are available for cleaning up after a stripping shovel. All shovels are tread equipped and operate under their own power. Stripping and waste rock is loaded into 30 cu yd air-dump steel cars, while mill rock is transported by 16 or 20 cu yd side-dump steel cars.

The initial workings of the mine were on a hillside, but since then the mine has taken the form of an inverted truncated cone. The appearance of the mine was dictated by the shape of the ore body and the mining methods used. At present, the spiral bench is being employed and consists of mining with power shovels outward and laterally from the sinking cut. The various levels are 35 ft apart vertically. A 180° inclined approach connects the levels. Mining limits are established for each level and the levels mined back to the boundaries successively from the top downward. A minimum track bench of 35 ft is left around the perimeter of each level. The horizontal distance from the crest of one level to the crest of the next is never reduced to less than 60 ft.

Wood is not allowed in the mining area for building and other purposes because wood fiber destroys the value of the asbestos. Ties, cabins, ladders, towers and other installations and equipment are made of steel. Extreme care is also exercised to exclude other foreign material which might damage equipment or the final product. Steam engine operators are not permitted to dump ashes in the pit and drip pans are installed under any equipment which may drip oil or grease.

Drilling and Blasting

Drilling in the open-pit is done with 4-in. drifter machines mounted on steel towers to support 40-ft lengths of 1½-in. hollow drill steel. Blastholes are drilled about 15 ft back from the face of the cut and slope toward the face at a 10 to 15° angle. Spacing of the holes along the cut is 3 to 6 ft depending upon the rock encountered. The drilling is carried about 4 ft below the grade of the next lower bench so as to reduce the size of the rib on the floor. The 40-ft holes are collared with a 4½-in. bit to permit use of a casing for the first 18 in., and the hole is bottomed at 2¾ in. diameter.

About 40 lb of 40 pct gelatin per hole is the average load for the primary blast. The cartridges used for loading are 2x16 in. The powder factor for the primary explosives is about 6 tons of rock per lb of gelatin.

After blasting, all the long asbestos fiber is hand-picked at the loading face. These fibers are the most valuable of the chrysotile. In the early days of asbestos mining these hand-picked fibers constituted the production of the mines in the serpentine belt.

Primary drilling units, equipped with dust collectors, drilling holes sloped at 10 to 15 degrees towards the face. Dust can be seen escaping from the hoses in the background.

Engineering Graduates Find Jobs Plentiful

by William B. Plank

THERE are 19 pct fewer undergraduate and graduate mineral engineering students enrolled in the ECPD accredited schools of the United States this year than there were a year ago. The figures are: 8727 this year and 10,674 last year. The entire engineering group in both countries numbers 171,070, as compared with 184,547 last year and 252,250 in 1947-48, the peak year. This is a decrease of 7.3 pct since last year, less than half as much as the decrease in the mineral engineering group. These figures on engineering enrollment for the current year, 1951-52, in colleges of the United States and Canada were prepared jointly by the U. S. Office of Education and the American Society for Engineering Education.

The seriousness of the situation is shown by the reported demand for 60,000 to 90,000 engineers this year for civilian and defense industries and only 35,800 will graduate next June. Many of the 1952 graduates are subject to Selective Service, having been granted deferments while in college, and ac-

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Table I. Undergraduate and Graduate Engineering Enrollment by Courses and Classes United States and Canada, 1951-52, 199 Schools

ECPD Schools	Courses	Fresh.	Soph.	Jr.	Sr.	5th Year and Others	Total Under-grads.	Grad. Std's	Grand Total
31	Mining	198	286	340	430	13	1,267	71	1,338
46	Metallurgical	363	512	568	590	196	2,237	759	2,996
31	Pet. & N. Gas	537	565	636	747	59	2,534	166	2,699
14	Ceramic	117	133	130	180	21	581	86	667
22	Geological	178	235	233	283	9	938	89	1,027
Total Mineral Engineers, U. S.		1,393	1,731	1,897	2,230	298	7,557	1,170	8,727
105	Chemical	2,647	2,397	2,575	2,809	1,148	11,576	2,503	14,079
134	Civil	4,178	3,989	4,545	5,118	1,914	19,744	2,057	21,801
129	Mechanical	5,564	5,411	5,731	6,548	3,860	27,134	3,286	30,420
134	Electrical	5,107	4,928	5,172	5,831	3,426	24,564	5,402	29,966
60	Industrial	794	945	1,253	1,583	492	5,067	1,511	6,578
36	Other Engrs.	4,074	3,318	3,392	3,567	1,373	15,724	3,073	18,797
	Unclassified	10,380	689	172	26	5,724	17,001	325	17,326
148	Total Engrs. ECPD SCLS	34,147	23,408	24,757	27,820	18,235	128,367	19,327	147,694
44	Other U. S. Engr., School	5,424	3,333	2,788	2,902	3,183	17,630	313	17,943
192	Total U. S. Engineers	39,571	26,741	27,545	30,722	21,418	145,997	19,640	165,637
7	Total Canadian Engrs.	1,342	1,063	923	1,344	532	5,204	229	5,443
199	Grand Total U. S. and Canada	40,913	27,804	28,468	32,066	21,950	151,201 (c)	19,869 (d)	171,070

(a) Includes 23 Women
(b) Includes 5 Women
(c) Includes 584 Women; 561 in U. S. and 23 in Canada
(d) Includes 64 Women, all in U. S.

Table II. Engineering Student Enrollment Comparison, 1940-41 to 1951-52 — Undergraduates and Graduates

Courses	1944-45	1947-48	1948-49	1949-50	1950-51	1951-52
Mining	224	2,459	2,256	2,223	1,697	1,338
Metallurgical	472	4,121	4,055	3,867	3,511	2,996
Petroleum	276	4,665	4,533	4,175	3,321	2,699
Ceramic	190	1,108	1,206	998	886	667
Geological	†	†	†	†	1,349	1,027
Fuels	†	†	†	†	†	†
Specials	†	†	†	†	†	†
Total Mineral Engineers U. S.				11,283	10,674	8,727
U. S. and Canada	1,262	12,353	12,050			
Chemical	5,082	26,972	23,619	19,976	16,323	14,079
Civil	3,537	31,849	33,861	29,109	24,505	21,801
Mechanical	6,965	56,551	53,642	54,632	35,347	30,420
Electrical	5,934	56,406	53,774	45,711	34,105	29,968
Industrial	†	†	†	†	†	6,576
Others	18,852	68,117	72,969	68,001	50,308	36,123
Total Engrs. ECPD Schools, Other						147,694
U. S. Engrs.						17,943
Total U. S. Engineers				218,712	180,262	165,637
Canadian Engrs.				6,821	4,285	5,433
Total Engrs. U. S. and Canada	41,632	252,250	249,915	226,533	184,547	171,070

cordingly industry may find itself with a deficit of from 40,000 to 60,000 engineers.

The shrinkage in the number of engineers receiving their bachelor degrees in the United States and Canada began with last year's graduating class, and is expected to continue until 1960. From present enrollments it can be foreseen that the curve of graduates will continue to decline until June 1955 when the present freshmen class of 40,913 will graduate. But, of this number not more than 20,000 are expected to finish their college work. The trend of graduates beyond 1955 will, of course, depend upon the size of the entering classes. It is not expected that they will reach the normal prewar rising curve until after 1960.

The number of mineral engineering graduates that will be available from the United States' schools next June is estimated to be 2317. This is computed by adding to the number of seniors those that are in the fifth year of the five-year programs. They are as follows: Mining engineers 434, Metallurgical engineers 646, Petroleum engineers 753, Ceramic engineers 196, and Geological engineers 288. Prospective employers of these men would be well advised to contact them early. In fact the personnel representatives of many companies are already in the process of doing just that.

Table III. Graduate Engineering Enrollment 1951-52, United States and Canada
(From Journal of Engineering Education, Feb. 1952, Advance Data)

	Degrees Conferred 1950-51			
	Masters	Doctor	M. S.	Ph.D. or Dr.
Mining	62	9	44	3
Metallurgical	507	252	507	42
Petroleum	160	5	65	3
Ceramic	51	35	55	9
Geological	76	13	31	3
Total Mineral Engineers, ECPD	836	314	702	60
Chemical	1,865	628	741	176
Civil	1,829	228	655	57
Mechanical	2,900	386	920	90
Electrical	4,661	741	1,154	144
Industrial	1,383	128	267	7
Other Engrs.	2,350	733	526	101
Unclassified	317	8	44	16
Total for ECPD Schools	16,161	3,186	5,009	711
Total for Other U. S. Schools	313	—	22	—
Total for All U. S. Schools	16,474	3,186	5,031	711
Canadian Schools	164	65	139	35
Grand Total	16,638	3,231	5,160	746

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Many agencies have been publicizing to young men of college age the unusual opportunities that exist today in all engineering fields. It is evident from this study that the greatest needs are in the mineral engineering fields where there is the least crowding and where the opportunities for satisfactory careers are more numerous today than ever before in the nation's history.

Table IV. First Degrees Conferred, All Engineers, United States and Canada
(Data from Journal of Engineering Education)

1942-43	14,714
1943-44	11,155
1944-45	4,724
1945-46	8,219
1946-47	19,272
1947-48	30,018
1948-49	46,934
1949-50	54,441
1950-51	43,762(a)
1951-52	35,800(b)

(a) United States—41,893, Canada 1896, Includes 80 Women, 77 in U. S., and 3 in Canada
(b) Estimated

1952 Pacific Northwest Joint Conference

Spokane, Wash., May 8 to 10, 1952

The 1952 Pacific Northwest Joint Conference—fifth annual meeting of the Industrial Minerals Div. and first meeting of the Metals Branch—will be held May 8 to 10 at the Hotel Davenport, Spokane, Wash. This conference, which was started as a one day meeting, has grown to a three day session. Sessions will be held on Extractive Metallurgy, Physical Metallurgy, Mineral Industries Education, Industrial Minerals, and Iron and Steel. F. R. Morral is Chairman of the Metals Branch meeting and R. G. Vervaeke is Chairman of the Industrial Minerals meeting.

It is the desire of the conference committees to serve the mineral industry in this industrially expanding section of the country. While sponsored by AIME branches, divisions, committees, with the full support of the members, a cordial invitation is extended to all persons who have an interest in mining or metallurgy. Members of professional societies allied with these industries are welcome to benefit from the extensive program offered.

A special objective of the committee is to encourage participation of students and faculty members. To this end, arrangements are being made to provide transportation, plant trips, and other financial and educational aids for students.

The conference will end with a banquet on Saturday evening, May 10. At the dinner, James F. Bell, president, Portland Gas & Coke Co., Portland, Ore., will speak on *Quartz and Mica Mining in Brazil.*

The Spokane Chapter of WAAIME is planning a leisurely program for the ladies attending the Conference. Serving on the Local Committee for the Conference are D. L. Myers, Registration; R. O. Oscarson, Finance; W. S. Peterson, Publicity; H. P. Sherman, Hotel and Meetings; R. A. Watson, Plant Visits and Transportation; and Mrs. C. G. Sherwin, WAAIME.

It will be necessary for security reasons, that all planning to go on the plant trips register in advance.

THURSDAY, MAY 8

9:00 am

Registration

1:30 pm

Plant Visits at Mead

1—Government magnesium reduction plant, operated under contract by Pacific Northwest Alloys Corp.
2—Aluminum reduction plant of Kaiser Aluminum & Chemical Corp.

FRIDAY, MAY 9

9:00 am and 2:00 pm

Extractive Metallurgy Sessions

Chairman: A. Y. Bethune, Assistant Superintendent, Electrolytic Zinc Plant, Sullivan Mining Co., Kellogg, Idaho.

Gas Handling, Dust Collection, and Dust Treatment at Trail: Metallurgical Staff—R. R. McNaughton, Manager, Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, B. C.

Bureau of Mines Electric Smelting Research Facilities and Activities at Albany: R. T. C. Rasmussen, Chief, Ferrous Metals Branch, U. S. Bureau of Mines, Albany, Ore.

Electrolytic Manganese Dioxide: W. C. Aitkenhead, Chief, Mining Experiment Station, State College of Washington, Pullman, Wash.

Operations at Garfield: R. Thompson, Superintendent, Garfield Plant, American Smelting & Refining Co., Garfield, Utah.

Converting Granulated Dross Reverberatory Speiss and Matte at Tooele: Metallurgical Staff—B. L. Sackett, Manager, International Smelting & Refining Co., Tooele, Utah.

Reverberatory Practice at McGill: Edward Pesout, Smelter Superintendent, Nevada Mines Div., Kennecott Copper Corp., McGill, Nev.

Tri-Stage Crystallization Process for Utilizing Western Ferrophosphorus: L. H. Banning, W. E. Anable and R. T. C. Rasmussen, U. S. Bureau of Mines, Albany, Ore.

Treatment of Roaster Reverberatory Flue Dust From a Copper Smelter: J. A. Finlay, Assistant Professor, University of Washington, Seattle, Wash.

Oxidation of Galena in an Aqueous Caustic Medium: J. E. Anderson, J. Halpern and C. S. Samis, University of British Columbia, Vancouver, B. C.

9:00 am

Physical Metallurgy

Chairman: Ray Ward, Head, Metallurgy Nucleonics Dept., General Electric Co., Richland, Wash.

Transformation in Co-Ni Alloys: J. B. Hess, Kaiser Aluminum & Chemical Corp., and C. S. Barrett, Institute for the Study of Metals, Chicago.

Correlation of the Band Properties of Metals: M. A. Cook, Professor, University of Utah, Salt Lake City.

Preferred Orientation and Directional Properties of 2S Aluminum: K. T. Aust and F. R. Morral, Kaiser Aluminum & Chemical Corp., Spokane, Wash.

Theory of Dendritic Growth in Metals: D. McLachlan, Professor, University of Utah, Salt Lake City.

X-ray Diffraction Techniques for Heavy Metals: J. H. Bach, General Electric Co., Richland, Wash.

1:30 pm

Plant visit to rolling mill of Kaiser Aluminum & Chemical Corp. at Trentwood.

3:30 pm

Faculty and student visit to rolling mill.

8:00 pm

Mineral Industries Education

Chairman: J. P. Spielman, Dean, State College of Washington, Pullman.

Trends in the Undergraduate Curricula: Joseph Newton, Professor, University of Idaho.

Trends in Graduate Training and Specialization: J. R. Lewis, University of Utah.

SATURDAY, MAY 10

9:00 am

Industrial Minerals

Chairman: R. G. Vervoeke, U. S. Gypsum Co., Evans, Wash.

Mining Phosphate Rock: C. W. Sweetwood, Mine Superintendent, Simplot Fertilizer Co.

Vermiculite: J. B. Myers, Vice-President, Zonolite Co., Libby, Mont.

Industrial Carbon: B. W. Gamson, Director, Engineering & Research Lab., Great Lakes Carbon Corp.

Garnets: Professor McDevitt, Idaho Bureau of Mines, Moscow.

9:00 am

Physical Metallurgy

Propagation of Slip Lines in Face Centered Cubic Metals: H. Czyzewski, President, Metallurgical Engineers, Inc., Portland, Ore.

High Pressure Oxidation Rate of Metals—Copper in Oxygen: W. McKewan and W. M. Fassell, Jr., University of Utah.

Parabolic-Linear Oxidation Rate Transition Theory: W. McKewan and W. M. Fassell, Jr.

Corrosion of Aluminum: R. S. Dalrymple, General Electric Co., Richland, Wash.

11:00 am

Women's Auxiliary (WAAIME)

Brunch

2:00 pm

Iron and Steel

Chairman: J. G. Johnston, Chief Metallurgist, Bethlehem Pacific Coast Steel Corp.

Raw Materials for Steelmaking in the Western States: S. G. Sargis, Supervisor, Raw Materials, Geneva Steel Co., Salt Lake City.

Electric Furnace Melting Practices for Low and High Alloy Steels: James Gow, Chief Metallurgist, Electric Steel Foundry Co., Portland, Ore.

Production and Properties of Aluminized Steel: J. B. Russell, Kaiser Aluminum & Chemical Corp.

Adaptation of Instrumentation to Metallurgical Control Processes: L. W. Heinzinger, Metallurgical Supervisor, Bethlehem Pacific Coast Steel Corp.

Utilization of Domestic Chrome and Manganese Ores: H. A. Doerner, Chief Metallurgist, California Bureau of Mines, Region III.

2:00 pm

Industrial Minerals

Industrial Utilization of Iron Oxide: J. M. Orr, Orr Chemical & Engineering Corp., Scappose, Ore.

Place of Coal Burning Steam Plants in the Northwest: Floyd D. Robbins, Professor, University of Washington, Seattle.

Use of Olivine in Earthenware and Semi-Porcelain Bodies: J. E. Dore, Kaiser Aluminum & Chemical Corp., P. D. Johnson, Boeing Aircraft Co., and J. I. Mueller, University of Washington.

Hot Pressing of Clay Products: Howard McDonald, University of Washington.

Evening

Banquet

Speaker: James F. Bell, President, Portland Gas & Coke Co., Portland, Ore., *Quartz and Mica Mining in Brazil.*

Solid Surface Energy and Calorimetric Determinations Of Surface-Energy Relationships for Some Common Minerals

by A. Kenneth Schellinger

THE terms *surface tension* and *surface energy* are well known when applied to liquids and are generally described by referring to the excess energy of the air: liquid interface as a result of unsaturated molecular forces surrounding the surface molecules of the liquid due to the presence of the air phase on one side. Such unbalanced forces produce the familiar water droplet of spherical form and are generally summed up as a surface tension measured in dynes per centimeter which can be shown mathematically to be equal numerically to a corresponding surface energy expressed in ergs per square centimeter. A specific surface energy, however, is best thought of as the energy necessary to produce one unit of new surface on a substance. Hence, in producing a bubble in a flotation cell the impeller must supply surface energy corresponding to the air: liquid interfacial area on the interior of the bubble. Inasmuch as it is relatively easy to extend or contract the surface of a liquid, there are a number of successful methods for liquid surface tension, or energy, measurement based upon surface deformation. This happy state of affairs does not, however, extend to solids, which are considered to possess surface energies for the same reasons as do liquids, i.e. because of unsaturated ionic bonds at the solid: gas interface.

As in the case of the flotation cell producing surface on liquids as new bubbles, it takes energy to produce new surface on solids as new particles. As every mill man knows, this surface is produced on mineral solids in a grinding mill by the action of a tumbling mass of iron balls. But here so much energy usually is wasted by the inefficient action of these balls that a large amount of heat is generated, and the surface energy production may be easily confused with the energy necessary to produce this ineffective heat. The tumbling balls and fracturing minerals ultimately take their energy from a rather large electric motor. It has been variously estimated that from 10 to 20 pct[1-4] only of this energy from the motor does not appear as heat and may be presumed to appear as surface energy on the minerals present. Such a production of new surface on the mineral phases is accompanied, of course, by a size reduction that is inevitable as more and more mineral interior molecules become surface molecules by the fracture exposure. This size reduction of mineral particles, although the most obvious feature and perhaps the sole object of the milling operation, is from this energy viewpoint the outward manifestation of the production of surface energy only.

Measurement of the characteristic surface energies of pure minerals and their various mixtures in ores would be a step towards understanding of the energetics of the commercial grinding operation. In addition, the characteristic surface energy of a mineral is probably a physical property specific for that mineral, and therefore, from a scientific standpoint, should be measured. It is interesting to note that, in contrast to the large body of work on the surface tensions of liquid systems and biological systems, the field of solid surface energies has been neglected. Prior to 1920 it is difficult to find more than one or two references to work on solid surface energies in *Chemical Abstracts*. Since 1920 such references number somewhat less than 100, while those on liquid systems are numbered in the thousands.

Much of this apparent neglect of the field of solid surface energies (the term is intended to be somewhat inclusive at this point and refers both to the solid: gas, and the solid: liquid interface) is because of the lack of a reliable method of measurement rather than any lack of scientific curiosity. It was, and still is, difficult to produce new surface on a solid without the simultaneous production of interior changes in the same solid which may consume part of the energy used. The extension in the surface area can be measured, but the interior crystal-

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Fig. 1—Components of the grinding calorimeter.

lographic changes are more subtle and not so susceptible to measurement. Experimental methods that have been used to determine the surface energies on solids include:

1—The production[4] of a balancing effect between a weight and the surface tension of a vertical fiber of the amorphous solid used to suspend it in space. Surface tensions of pitch and glass were thus found to be in the neighborhood of the measured value for water, about 72 dynes per cm.

2—A method based on the use of the Gibbs-Thomson[5] derivation:

$$RT \ln X_r/X = 2MY/rd$$

where, X_r is the enhanced vapor pressure of very small (<1u) particles. X is the vapor pressure of a flat surface of the same solid. M, Y, r, and d are molecular weight, surface tension, radius and particle density respectively. Measurements[6] of vapor pressures and particle radii were made for some oxide and carbonate salts, which yielded calculated values for their surface tensions of 100,000 to 750,000 dynes per cm. These values have been looked upon as high by other workers in the field but check in order of magnitude those values found through grinding experiments.

3—A method based upon measurement of the heat[7, 8] of solution of a soluble salt such as NaCl. Measurements made by this method range from about 400 ergs per cm[2] for NaCl to more than 8000 for $Mg(OH)_2$.

4—A solubility method based on a derivation from the Gibbs-Thomson equation given under 2. It was found that the very small particles of a soluble solid have a higher solubility than the larger due to the increased surface energy of the former. Dundon[9] used this method to obtain the surface energy of $BaSO_4$-1250 ergs per cm[2] and that of CaF_2-2400 ergs per cm[2].

In addition to such direct attempts at measuring solid surface energies, some physicists have made calculations of surface energies of solids based on ionic field theory. Alkali halides, which have space lattices made up of two kinds of ions alternately arranged, lend themselves particularly to this type of calculation. Madelung, Born, Stern, Biemuller[10] and others have found values ranging from 100 ergs per cm[2] for NaI to 417 ergs per cm[2] for NaF by considering the lattice as an array of point charges in space interacting directly and indirectly as dipoles, quadrupoles, etc. Such calculated values for solids were found on comparison to the measured molten values for the same salts extrapolated to the same temperature to be only slightly higher.

Edser[11] used known physical constants of solids (compressibility, thermal expansion, and density) to estimate surface energies for quartz and pyrite, obtaining values of 920 and 1175 ergs per cm[2], respectively. These values in addition to being lower are reversed in magnitude from the finding of investigators in the field of comminution.

Interest in the surface tensions of metals has led to a number of calculations and measurements on these ductile solids. Tammann and Bohme measured the surface tensions of gold strips and thus assigned pure gold a value of about 1600 dynes per cm at room temperature. Recently, Udin, Shaler, and Wulff[12] used a somewhat similar method to determine the surface tension of solid copper and so obtained a value of about 1800 dynes per cm at room temperature. Fricke[13] developed an equation for calculating the specific surface energies exposed on certain planes of atoms in solid metals. His calculated value for the (111) plane of solid copper was 2535 ergs per cm[2] at absolute zero. This value is not unreasonable when compared with the measured value of 1800 at room temperature, inasmuch as the temperature coefficient would lower Fricke's value somewhat. Incidentally Fricke also calculated a value of 3696 ergs per cm[2] for the (001) plane of Ni, and one of 3980 ergs per cm[2] for the same plane of atoms in alpha Fe.

Such values for ductile, soft metals such as copper and gold are seen to be higher than those estimated for hard substances such as quartz and pyrite. This situation is not only contrary to experience but is not very likely to be valid. In any case no direct measurement of the surface energy of quartz, a common ore mineral, has been reported as such, although Edser's value[11] is not the only estimate that has been made. Sutherland,[14] in a recent review of the topic of solid surface energies, sums up the situation by saying "the lack of precise data on the surface tension, or total surface energy, of a solid is a real hindrance in the study of processes such as catalysis, adsorption and cohesion, and it leads to even greater difficulties in dealing with still more complex problems such as crushing and grinding."

The Grinding Calorimeter

A grinding calorimeter shown in Figs. 1 and 2, described in a previous paper,[2] was designed to give an accurate measure of all of the heat energy output from a small tumbling mill using cast-iron shot as the grinding medium. The kinetic energy input was obtained from a special recording torquemeter that indicated the net torque exerted continuously by the tumbling mass. Suitable calibrations and precautions, such as the use of an air thermostat container, gave an instrument capable of a balance of unloaded energy input against heat energy output within a fraction of a percentage. Here, with only the cast-iron shot in the tumbling chamber, the kinetic energy input was changed completely to

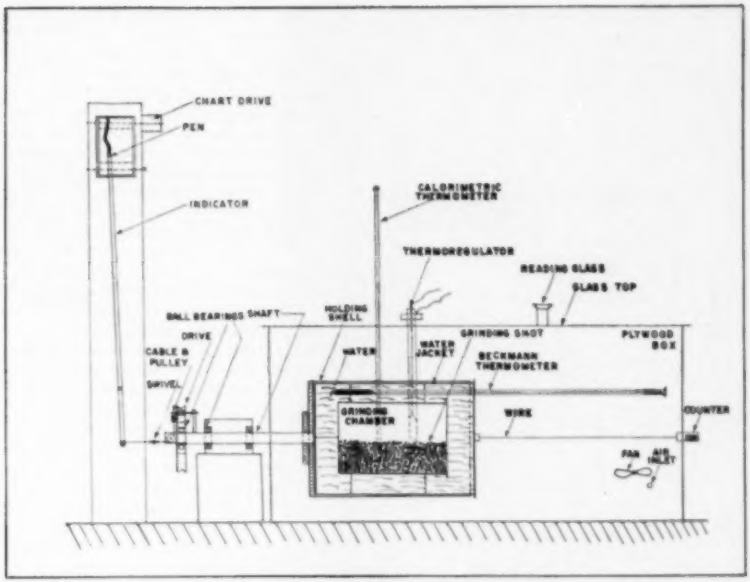

Fig. 2—Assembled grinding calorimeter.

heat energy by collision and by frictional rubbing. The resultant heat energy passed into the water jacket surrounding the tumbling chamber and caused a temperature rise on a Beckmann thermometer immersed therein.

Introduction of several hundred grams of a brittle material, such as quartz sand, into the tumbling chamber upset this energy balance to the extent of some 10 to 20 pct. That is, the output heat energy was less than the input kinetic energy by this percentage of the input. It seemed reasonable to postulate that this disappearance of energy was caused by the creation of surface energy within the tumbling chamber—an energy absorption from the tumbling system. This quantity of energy was then taken as the total created mineral surface energy in calories. To translate this total into a specific energy figure for the mineral, it was necessary to measure the extent of the surface created during the absorption of a given amount of energy. This was done by the use of the BET method of gas adsorption isotherms, a method which has found wide application in recent years.

Surface Area Measurement

The surface, or air:mineral interfacial area, produced on the mineral while grinding in the calorimeter tumbling chamber was similar to that on any ground mineral. That is, it probably consisted of cleavage planes, incipient cracks, re-entrant angles, peaks, and valleys, and corners, all on a submicroscopic scale. Methods for estimating the area of this surface are numerous, but generally are of low accuracy. Many of them are based upon a plotted sizing analysis of the ground mineral from which a mathematical expression giving the size distribution is derived. An assumption as to regular geometric shape followed by a suitable correction factor, designed to allow for irregularities, produces a calculated figure for the surface area which may or may not be within 100 pct of the true value. Such methods obviously must fail where the material is porous or of a very irregular shape. More direct methods depend upon the particles interfering with transmitted light, or upon the surface film of fluid which forms on all solid:fluid interfaces resisting the passage of the main body of fluid through a mass of the particles. This latter method, or permeability method, is capable of yielding rapid results after proper calibration, but pores and cracks in particles are not taken into account during the surface measurement, especially if present on atomic dimensions. A tedious method for homogeneous material based on Wenzel's law, which says that initial solution rate is proportional to total surface exposed, is capable of giving accurate results if proper calibrations are made and a suitable solvent is found for the material.

The discovery of monolayer and multilayer adsorption of gas molecules at low temperatures on solid surfaces in contact with the gas phase led to newer methods of estimating the area of such solid surfaces. The most successful of these methods, known as the BET, was developed by Emmett,[11] Brunauer, and Teller some 15 years ago and was later applied to minerals by Gaudin and coworkers.[12] This method was based upon a firm theoretical derivation which yielded an equation that checked experimental work in a satisfactory manner.

The BET theory and derived equation make it possible to calculate the volume of gas going to make up the monolayer by plotting functions of pressures and volumes as parameters to obtain a straight line whose slope is proportional to the volume condensing as the monolayer, see Fig. 3. Such a straight line is widely regarded as verification of the multilayer adsorption mechanism. Furthermore, it can be obtained rather easily with a large num-

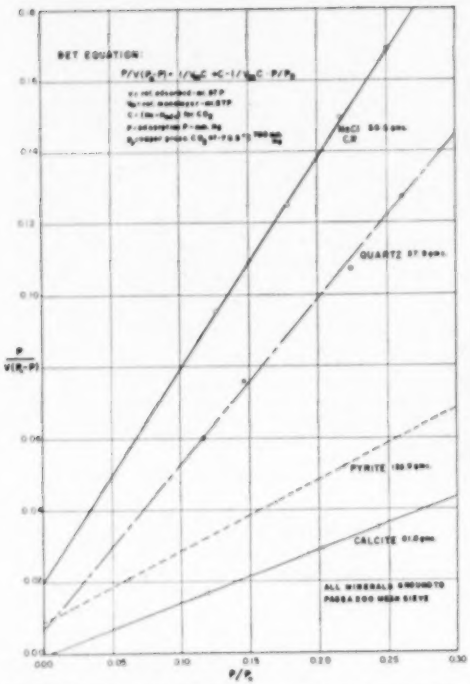

Fig. 3—BET plots of CO_2 adsorption runs on various mineral powders.

ber of solids and gases, provided a suitable measurement apparatus is used, see Fig. 4. Although objections can be found to this method of surface measurement on fine particles, time has confirmed the validity of the method by a large body of comparison data which seems consistent. As it is generally accepted as giving the closest approximation to the true interfacial area of fine irregular mineral powder obtainable at present, it was used in this experimental work on mineral surface energies.

Nitrogen gas, adsorbed at liquid nitrogen temperatures, is generally used as the measuring gas, or adsorbate, for measurement of the surface on mineral powders. Emmett, in his original work on the BET method, reported adsorption isotherms obtained with a number of gases on several different substances such as oxide catalysts and carbon blacks. All of these isotherms were of the S-type and conformed to the BET theory and equation. One of the gases used was carbon dioxide at the sublimation temperature of dry ice (−78.5°C). Dry ice, in contrast to liquid nitrogen, is readily available, comparatively inexpensive, and easy to handle. For this reason medical CO_2 was chosen as the adsorbate, or measuring gas, in this work on mineral surface energies. Good isotherms, and BET plots, were obtained on all minerals investigated. Fig. 3 illustrated BET plots for CO_2 adsorbed on quartz, salt, pyrite, and calcite. As far as the author knows, this is the first use of CO_2 as a measuring gas for surface areas in mineral work; no special advantages other than those mentioned above are claimed for this gas, although it seems to give just as satisfactory results as nitrogen.

Calibration of the method was attempted by several procedures, although the BET method theoretically needs no calibration. Gaudin and Bowdish[16] found that they could check the calculated surface on carefully prepared glass beads by their nitrogen gas method if solid-type packing of the adsorbed molecules was assumed. Other investigators had found also that solid-packing molecular areas seemed to check more closely with areas deduced by other methods than did liquid-packing molecular areas. The calculated solid-type molecular area of one CO_2 molecule is 14.1 sq Å and was used as the basic area unit in the present experimental work.

The present BET adsorption measurements with CO_2 gas at −78.5°C were compared with surface area measurements made by the air permeability method, by the HF dissolution method of Gross and Zimmerly, and by a sizing analysis made with a Roller air analyzer. A standard Portland cement powder, No. 114f, of the Bureau of Standards was used first. The BET method with CO_2 gave a surface area of 3770 sq cm per g as compared with the 3230 reported by the Bureau as obtained by the Blaine air-permeability method. Sized quartz sand between 65 and 100 mesh and also −200 mesh was run by the dissolution method of Gross and Zimmerly[17] with hydrofluoric acid as the solvent. Their calibration factor of 170 was used to convert initial dissolution rate (IR) to specific surface area. This factor had been worked out by means of a silver plating technique on a large regular shape of quartz. Areas obtained by the dissolution method and the corresponding areas obtained by the BET adsorption technique were as follows:

	Dissolution	BET CO_2	BET Ethane (18)
−200 mesh quartz	2460 cm²/g	1890 cm²/g	
−65 + 100 quartz mesh	374 cm²/g	310 cm²/g	286 cm²/g

Experimental Procedure

Combination of the calorimetric energy determination technique[5] and the BET surface area measurement technique promised to give further experimental data on surface-energy relationships in the comminution of common minerals. Techniques[17, 19] for obtaining such data on a number of minerals had been published somewhat earlier. However, these earlier methods had employed drop-weight crushers for energy measurements. Plots of new surface produced versus the energy input held responsible for that surface had resulted in straight lines passing through the origin of such plots. Each straight line represented a different mineral and had a unique slope. This characteristic slope, termed the Rittinger coefficient of the mineral, can also be thought of as the surface energy of the mineral if one accepts the premise that substantially all of the absorbed energy goes to new surface rather than to heat production and to the production of internal lattice rearrangements in the mineral. Such plots, originally presented by Gross and Zimmerly[17] were also adopted by the author to derive the surface-energy relationships for quartz glass sand, crystalline NaCl, specimen-grade pyrite, and specimen-grade calcite.

In general, the same experimental procedure was used for each mineral. The coarse mineral was ground in a pebble mill, which was lined with por-

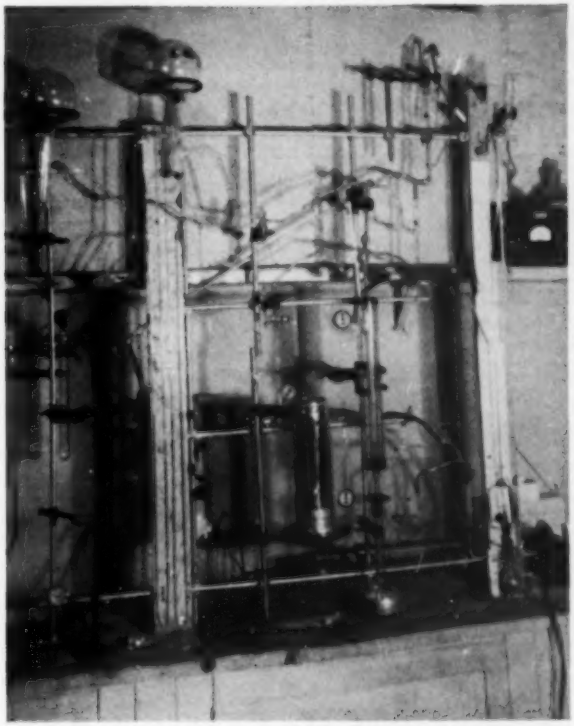

Fig. 4 — Adsorption apparatus for surface area measurement with CO_2 gas.

celain and charged with Danish flint pebbles, until it passed a 200-mesh sieve. After mixing the sieved mineral thoroughly on a mixing cloth a large sample was taken at random and enclosed in the adsorption tube, see Fig. 4, for a surface area determination. This sample ranged from 50 to 150 g of the powdered mineral, dependent on the specific gravity and size. The total surface on the mineral charge was determined by use of the BET method with CO_2 as the adsorbate. Reproducible area determinations were easily made on mineral samples that had been passed through the 200 mesh sieve. A standard 300-g charge of the mineral was placed in the grinding chamber of the calorimeter with about 3000 g of chilled cast-iron shot. A calorimetric run was then made on the material, and the energy absorption due to the creation of surface energy was calculated. This procedure has been described in an earlier paper.[3] The net quantity of energy absorbed as surface energy could be varied by changing the time of the run. Each calorimetric run, then, corresponded to one point on the surface-energy plot.

The ground charge was removed from the calorimeter chamber and screened from the shot, mixed thoroughly, and a large sample used for another surface determination in the BET apparatus. The net surface produced in the calorimeter then was obtained by subtracting the total surface charged to the chamber from the total surface discharged from the grinding chamber. This net figure was used as the surface parameter on the surface-energy plot.

The experimental points resulting from the foregoing procedure are plotted as Fig. 5. Energy was converted to ergs as this is the commonly used unit for surface energies, although it is inconveniently small in the case of solids. Surface area is, of course, in square centimeters. The figure presents the points for each mineral averaged as a straight line. The slope of each of these lines is the surface-energy relationship, or the surface energy within the assumptions outlined, of the mineral concerned. These relationships then can be summed up numerically, as follows:

Mineral	Ergs per Cm^2	Moh's Hardness No.
Quartz	107,000	7
Pyrite	60,000	6
Calcite	32,400	3
Halite (C.P. NaCl)	26,100	2.5

The order of arrangement and magnitudes are seen to be in substantial agreement with the hardness of the minerals on the well-known Moh's scale with the exception of quartz. Moh's scale, devised at least a century ago, assigns a maximum value of 10 to diamond as the hardest known substance and has been criticized as nonlinear on the grounds that diamond should be assigned a much higher value, in conformity with its actual hardness.

The method of averaging the points on the surface energy plot is thought to give a more accurate figure for the final surface energy relationship shown by each mineral than could be obtained by adding separate determinations and dividing by the total number. The origin of the plot is thought to be a significant point in the determination. With a brittle

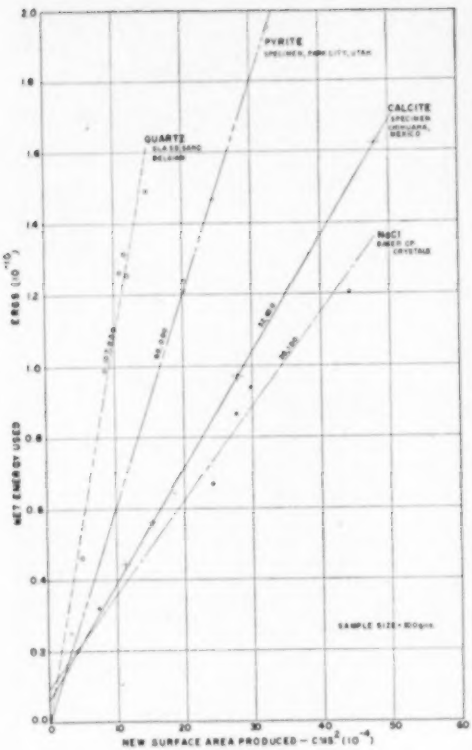

Fig. 5—Surface energy plots for quartz, pyrite, calcite, and NaCl.

mineral, such as quartz, unless the scales used for both the energy units and surface units are quite detailed, the surface energy line should normally pass through the origin or quite close to it. This would not be true if the mineral were ductile, that is, absorbed considerable energy by the internal processes of twinning and gliding for this energy then obviously would not show up as new surface. The surface energy line would be expected to intercept the energy axis somewhat above the origin, as indeed the lines do in the cases of NaCl and calcite, two minerals which have been found to exhibit ductile behavior in other investigations. The intersection shown in Fig. 5 for NaCl is about 10^{7} ergs or, on the basis of a constant 300 g of sample, about 3.3x 10^{7} ergs per g. Such a figure would represent the maximum energy stored during work hardening of the NaCl crystals during grinding. It is interesting to note that copper and brass, ductile metals, store approximately ten times this amount (about 3x10^{8} ergs per g) as cold work prior to fracture. Therefore the energies of lattice dislocation stored by calcite and halite as shown by the present calorimeter investigations are at least in qualitative agreement with previous experience. Quartz and pyrite were much too brittle to show other than a direct passage of the surface energy line through the origin of the plot in each case.

As was mentioned earlier, experimental data on the surface energies of solids in general and of mineral solids in particular are not numerous in the literature. Much of the work on minerals has been derived by the use of the drop-weight crusher for energy measurements and a variety of methods of estimating the resultant surface production. Most mineral workers do not claim to have measured surface energies directly and yet, for the sake of argument, if the drop-weight crusher is considered to be 100 pct efficient, then the data can be calculated to surface energies, as shown in Table I.

Table I. Surface Energies in Ergs Per Cm^2

Mineral	Present Work	Gross and Zimmerly[17]	Piret, et al[19]	Theoretical
Quartz	107,000	86,000	174,000[a]	920 (Edser)
			89,000[b]	520 (Martin)
Pyrite	60,000	43,400	None	None
Calcite	32,400	13,000	92,000[a]	None
Halite	26,100	None	89,000[b]	152 (Biemuller)

[a] Surface measurement by permeability method.
[b] Surface measurement by gas adsorption method.

The divergences shown by the experimental and theoretical data are impressive. No reliable clue has yet been discovered as to why such differences should exist. Certainly it is safe to say that much more work is needed in this interesting field to clear up the existing anomalies. The order-of-magnitude agreement found by mineral workers is a promising start in the direction of clarification of the vital question of the surface energies of mineral solids.

References

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Radiotracer Studies of the Action of Dithiophosphate In the Selective Flotation of Galena and Sphalerite Using $CuSO_4$ and NaCN

by C. M. Judson, A. A. Lerew, R. B. Booth, J. S. Kennedy, and G. L. Simard

DITHIOPHOSPHATE collectors are commonly used in the flotation of sulphide minerals. Studies of the interaction of a typical dithiophosphate collector with galena surfaces have been previously reported from these laboratories.[1,2] These fundamental studies were carried out by employing phosphorus labeled radioactive dithiophosphate. Radioactivity determinations then could be used to measure readily and accurately the small concentrations of dithiophosphate that are present under conditions of flotation processes. Measurements were made on ground mineral, determining the amount sorbed indirectly from the concentrations in solution; and studies were also made with single crystals, determining the amount sorbed directly by counting the crystal surface. The rates, isotherms and reversibility characteristics of dithiophosphate sorption, the competition between phosphate and dithiophosphate for the mineral surface, and the exchange of sorbed dithiophosphate with dissolved dithiophosphate were studied.

These studies have now been extended by sorption measurements in flotations with a Fagergren machine. For this work, the selective flotation of galena and sphalerite from quartz was chosen, using ammonium di-(sec-butyl) dithiophosphate as the collector, sodium cyanide as depressant for sphalerite, and copper sulphate as an activator for sphalerite. While the selective flotation of galena and sphalerite using a single dithiophosphate collector is not typical of flotation practice (two different collectors are generally used), it was found that a reasonably good separation could be obtained by using zinc sulphate with the sodium cyanide in the galena flotation and by cleaning the sphalerite concentrate or by carrying out the sphalerite flotation in an alkaline medium.

Data of practical importance on the distribution of collector between the concentrates, tailings, and solutions were obtained, particularly with regard to the effect of copper sulphate and sodium cyanide. In addition to the selective flotation of galena and sphalerite from quartz, single flotations of galena-quartz and sphalerite-quartz mixtures were carried out, along with blank flotations on quartz alone. The present paper describes the results of these experiments. As in previous papers, the term sorption is used to designate uptake of collector by the mineral, without implication as to the nature of the processes involved.

Experimental

Materials: The mineral system was a ground synthetic mixture of galena, sphalerite, and quartz. The galena was from Galena, Kans., and contained 75 pct lead (theoretical 85.6 pct Pb for PbS); the sphalerite, from Ottowa County, Okla., contained 63 pct zinc (theoretical 67.2 pct Zn for ZnS); and the quartz from Klondike, Mo., analyzed as 99.97 pct SiO_2.

Sulphur labeled radioactive di-(sec-butyl) dithiophosphate was prepared from S^{35} supplied by the Oak Ridge National Laboratory on allocation from the U. S. Atomic Energy Commission. The synthesis consisted of precipitating barium sulphate, reducing the barium sulphate to barium sulphide, acidifying to form hydrogen sulphide, and oxidizing the hydrogen sulphide with iodine to elemental sulphur.

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The elemental sulphur then was combined with phosphorus to form phosphorus pentasulphide, and the ammonium dibutyl dithiophosphate prepared therefrom by the method previously described for the synthesis of the phosphorus labeled compound.[1]

Details of the synthesis were as follows: Carrier sodium sulphate was added to a solution containing 26 g of neutron irradiated potassium chloride in which the chlorine had been transmuted to sulphur. After digesting with hydrogen peroxide, barium sulphate was precipitated in 98 pct yield (534 mg). One half of this barium sulphate was mixed with an equal amount of charcoal (Darco-S-51) and covered with another 100 mg of charcoal, and the mixture was heated to 1100°C under nitrogen for 4 hr. The barium sulphide obtained was heated on a steam bath for 1 hr in a closed system with 30 ml of 3 M hydrochloric acid. The hydrogen sulphide evolved was carried in a stream of nitrogen into two successive traps containing 0.12 M potassium iodide, 0.009 M potassium iodate, and 2.5 M hydrochloric acid. The solution was then boiled for a few minutes to complete the removal of hydrogen sulphide. The excess iodine in the traps was removed by adding a freshly prepared clear solution of 0.1 M stannous chloride and digesting on the steam bath for 1 hr. The elemental sulphur was separated by centrifuging and was digested with a small amount of water to complete the removal of iodine. It was centrifuged again and then dried in a vacuum desiccator. The yield based on barium sulphate was 77 pct (28 mg).

The labeled sulphur was thoroughly mixed with 124 mg of nonradioactive carrier sulphur (USP flowers of sulphur), 66 mg of amorphous red phosphorus and 198 mg of carrier phosphorus pentasulphide, reagent grade, purified by extraction with carbon disulphide. The mixture was heated slowly under dry nitrogen to 270°C and kept at 270° to 300°C for 4 hr. The labeled phosphorus pentasulphide obtained was allowed to react with sec-butyl alcohol at 80° to 85°C. The crude dibutyl dithiophosphoric acid obtained was dissolved in heptane and filtered and the ammonium salt formed by reaction with anhydrous ammonia. On cooling, the ammonium dibutyl dithiophosphate separated as a crystalline product. The yield of air-dried product based on the total sulphur taken was 48 pct (453 mg).

Table I. Size Distribution in Ground Minerals

Taylor Screen Size	Galena-Quartz Wt. Pct	Sphalerite-Quartz Wt. Pct
+65	4.0	5.0
−65 +100	32.0	32.5
−100 +150	22.0	23.0
−150 +200	10.5	11.0
−200	31.5	28.5

Table II. Time for Conditioning and Flotation, Min

	Single Flotations		Selective Flotation
	Galena	Sphalerite	
NaCN, if added	5	5	5
$CuSO_4$, if added	5	5	–
Dithiophosphate	5	5	1
Pine oil frother	1	1	–
Flotation of galena	2	–	2
$CuSO_4$	–	–	5
Pine oil frother	–	–	1
Flotation of sphalerite	–	2	3

Two samples of nonradioactive ammonium di-(sec-butyl) dithiophosphate were used. One of these samples was prepared from Baker's phosphorus sulphide by a procedure similar to that used for the radioactive dithiophosphate. The second sample was a commercial product manufactured by the American Cyanamid Co.

The pine oil frother was Newport Industries, Inc., G.N.S. No. 5. The other chemicals used in the flotation tests were reagent grade chemicals.

Flotations: The flotations were carried out with 200 g of mineral in a Fagergren flotation machine having a 250-g cell. The galena, sphalerite, and quartz were crushed separately to pass a 10 mesh sieve, using a gyratory crusher for the quartz and a porcelain mortar and pestle for the galena and sphalerite. Synthetic mineral mixtures were made up with quartz to contain about 4.4 pct lead as galena or about 4.7 pct zinc as sphalerite, or to contain these amounts of galena and sphalerite together. The mineral mixtures were wet ground in a porcelain ball mill for 20 min with Danish pebbles at 30 pct solids, then immediately diluted to 20 pct solids, conditioned with the reagents required, and floated. The size distribution of the mineral is shown in Table I for two typical experiments.

The time and order of reagent additions for conditioning and the time for flotation are shown in Table II. In the selective flotation, a shorter time was allowed for conditioning with dithiophosphate, and the use of pine oil frother for the galena separation was omitted. A better separation was obtained in the selective flotation by making these changes in procedure. Except in one group of experiments in which a very large amount of quartz was obtained in the rougher concentrate, the rougher concentrate was not cleaned.

The concentrate and tailing samples obtained from the flotation experiments were immediately filtered in a Buchner funnel to separate the mineral from the solution for counting. In the single flotations with radioactive dithiophosphate, the amount of wash water used in transferring the mineral to the filter was kept at a minimum, and in the selective flotations with radioactive dithiophosphate, the wash water was omitted and the filtrate was used to wash the mineral onto the funnel. Although dithiophosphate can be desorbed quite readily by washing with water, it does not appear that there were any significant differences caused by the failure to use the filtrate for washing in all of the experiments.

Each flotation experiment was carried out separately with radioactive dithiophosphate and with nonradioactive dithiophosphate. The experiments with radioactive dithiophosphate were used to measure the sorption of dithiophosphate on the minerals and the concentration of dithiophosphate remaining in solution. The experiments with nonradioactive dithiophosphate were used to determine the lead and zinc content of the flotation products by chemical analysis. Separate experiments with nonradioactive dithiophosphate were carried out to avoid carrying out chemical analyses on the radioactive minerals. The dry weight of the filtered mineral samples was determined in all of the experiments. In the single flotations, the nonradioactive dithiophosphate was a special sample prepared by the same method as the radioactive dithiophosphate. In the selective flotations, the nonradioactive dithiophosphate was a sample of the commercial product.

Table III. Single Flotations Without Copper Sulphate Activation, 0.12 Lb Per Ton of Ammonium Di-(sec-butyl) Dithiophosphate (DTP) and 0.08 Lb Per Ton of Frother

Ore	NaCN, Lb/Ton	Concentrate		Sorption of DTP, Mg/G		DTP in Filtrate		
						Concentration, Mg/Liter		Amt., Pct of Total
		Wt, G	Pct of Total PbS or ZnS	Cons	Tail.	Cons	Tail.	
PbS-SiO_2	—	13.4	99.6*	—	—	—	—	—
	—	14.7		0.15	0.002	8	5	73
	—	12.9		0.03	0.002	11	7	81
	—	12.3		0.10	0.002	8	8	74
	0.10	13.8	98.6*					
	0.10	13.6		0.06	0.003	6	9	89
ZnS-SiO_2	—	11.4	47*					
	—	8.5		0.06	0.003	6	6	88
	—	7.3		0.03	0.002	8	10	93
	—	8.5		0.09	0.002	7	9	84
	0.10	2.2	7*					
	0.10	3.4	*					
	0.10	3.8	*					
	0.10	6.5		0.03	0.002	10	9	83
	0.10	5.0		0.05	0.003	7	10	90
	0.20	3.1		0.04	0.002	8	10	93
SiO_2	—	—		—	0.007	7	8	—
	—	8.7		0.13	0.008	8	7	72
	0.10	1.2		0.06	0.003	9	10	94

* Nonradioactive experiments.

Radioactivity Determinations: Radioactivity determinations for the mineral samples and filtrates were used to calculate the amount of dithiophosphate present, assuming that all of the radioactive sulphur was present as dithiophosphate.

These measurements were made with a mica-window Geiger counter. Solutions were analyzed by counting dried 0.1 ml aliquots under the mica-window tube. The total radioactivity present in each experiment was determined by dissolving the tagged dithiophosphate in 10.0 ml of water and counting an aliquot of a suitable dilution to which was added an equivalent amount of sodium hydroxide. The remainder of the 10 ml of solution was used for the flotation experiment. Filtrates were analyzed by adding to 100-ml portions a small amount of sodium hydroxide, which was equivalent to the amount of dithiophosphate that would have been present if no sorption had occurred, and by counting a suitable aliquot. More reproducible measurements were obtained when sodium hydroxide was added, presumably because loss by volatility in the drying process was less for the sodium salt than for the ammonium salt.

The sorption on the minerals was measured by counting thick mineral samples directly. A glass dish 5 cm in diam and 1.7 cm in height was used for low levels of radioactivity, and a cupped planchet 0.5 cm in height and 1.7 cm in diam was used for high levels. These were filled to a constant height with mineral. For samples of constant density, the count observed can be assumed proportional to the count per unit weight under some standard conditions at infinitesimal thickness. Since the thickness of the samples used was considerably larger than the range of the beta particles emitted by radioactive sulphur, the proportionality constant was to an approximation independent of the density and the thickness of the sample, although not of the distance from the top of the sample to the counter. The proportionality constant was determined empirically by two techniques. In one technique, a quantity of dry mineral was treated with a small measured amount of solution containing radioactive dithiophosphate, and after having been thoroughly mixed in a mortar and pestle, the mineral was counted. In the second technique, the mineral was suspended in solution and treated successively with dithiophosphate and with copper sulphate solution. The mineral was then filtered off and counted, with corrections allowed for the amount of dithiophosphate remaining in solution. With either technique a mineral sample was obtained with a known count per gram of mineral for standard conditions and infinitesimal thickness. The standard conditions were arbitrarily defined as those used for counting 0.1 ml aliquots of solution. The requirement of infinitesimal thickness was adequately met in counting 0.1 ml aliquots, since the total weight of salts in 0.1 ml was of the order of 1 to 10 mg.

The proportionality constant used in measurements of mineral concentrates was an average value obtained from four experiments with galena and sphalerite concentrates by the two methods described. The proportionality constant used in measurements of mineral tailings was a value obtained from experiments with a quartz tailing by the first method.

Results

Single Flotations without Copper Sulphate Activation: The data obtained in the single flotation of galena from quartz, of sphalerite from quartz, and of quartz alone are shown in Table III for all of the experiments in which no copper sulphate was added.

Flotation: The effectiveness of the separations accomplished was essentially as expected. The separation of galena from quartz under the conditions used was good (99.6 pct of the galena in the concentrate), while the separation of sphalerite from quartz was poor (47 pct of the sphalerite in the concentrate). Quartz was found in the concentrates from the galena-quartz and sphalerite-quartz flotations, and some quartz was also floated in the blank with quartz alone, but the amounts were not excessive in any of these experiments.

The addition of cyanide depressed the flotation of sphalerite from quartz, from 47 pct to 7 pct of the sphalerite in the concentrate, and the flotation of quartz in the blank, but the flotation of galena from quartz was not affected significantly. The weight of quartz floated along with the sphalerite and galena was not changed appreciably. The weight of quartz in the concentrate is calculated from the total weight of concentrate less the weight of galena or sphalerite based on a total of 11.5 g of galena or 14.9 g of sphalerite taken for flotation.

Although the weight of the concentrate using radioactive and nonradioactive dithiophosphate agreed satisfactorily for the galena-quartz system, it did not agree very closely for the sphalerite-quartz. In flotations without cyanide, the sphalerite concentrate obtained with radioactive dithiophosphate weighed appreciably less than the concentrate obtained with nonradioactive dithiophosphate. With cyanide, the concentrate obtained with radioactive dithiophosphate weighed appreciably more than the concentrate obtained with nonradioactive dithiophosphate. It appears that even though the procedures for the preparation of radioactive and nonradioactive materials were similar, there may have been some slight differences in the products. Because of this disagreement, the analyses of galena and sphalerite obtained with nonradioactive dithiophosphate may differ somewhat from those which would have been obtained in flotations with radioactive dithiophosphate.

Sorption: A major part, 72 to 95 pct, of the dithiophosphate present remained in solution in all of the experiments. The concentration in the solutions from the concentrate was in fair agreement with the concentration in the solutions from the tailing. The differences observed were not consistent.

The dithiophosphate sorption on the concentrate varied considerably between experiments. Values of 0.03, 0.10, and 0.15 mg per g were obtained in the flotation of galena without cyanide, and the values observed in the remaining experiments were all within the same limits. Except for the quartz flotation without cyanide, the dithiophosphate sorption on the tailing was relatively more consistent, 0.002 to 0.003 mg per g, and was lower than the sorption on the concentrate by a factor of at least ten.

There was no significant difference between the amount of dithiophosphate sorbed on concentrates of galena, sphalerite, or quartz. On the average, cyanide appeared to cause a slight depression of the amount of dithiophosphate sorbed on the concentrate: from 0.09 to 0.06 mg per g for galena flotation, from 0.07 to 0.04 mg per g for sphalerite flotation, and from 0.15 to 0.06 mg per g for the blank flotation of quartz). However, this depression of the dithiophosphate sorption on the concentrates was relatively small compared to the variations in replicate experiments. Because of the preponderance of quartz in the tailing, it was not possible to determine from the data whether there was any depression of the dithiophosphate sorption on the sphalerite in the tailing.

Single Flotations with Copper Sulphate Activation: The data obtained in the single flotations with copper sulphate activation are shown in Table IV. Galena can be separated readily from quartz without copper sulphate and therefore its activation was not studied.

Flotation: The effectiveness of the separations was again essentially as expected. With copper sulphate used as an activator, the separation of sphalerite from quartz was almost complete (99 pct of the sphalerite in the concentrate compared to 47 pct without copper sulphate). The depressant effect of cyanide on the flotation of sphalerite was overcome completely. The weight of quartz floated with the sphalerite and the weight of quartz floated in the blank with quartz alone were not increased significantly. Agreement in the weight of concentrate between experiments using radioactive and nonradioactive dithiophosphate was good.

Sorption: The amount of dithiophosphate remaining in solution was reduced from 72 to 95 pct of the total in experiments without copper sulphate to 2 to 4 pct with copper sulphate. Corresponding to this reduction in the concentration of dithiophosphate in solution there was an increase in the amount of dithiophosphate sorbed on the mineral (from 0.03-0.15 to 0.2-1.4 mg per g in the concentrate and from 0.002-0.003 to 0.01-0.04 mg per g in the tailing). The tailing here was essentially pure quartz.

Selective Flotations: The data obtained in the selective flotations are shown in Table V. Each selective flotation experiment consists of two parts: part G, the flotation of galena in the presence of cyanide, and part S, the flotation of sphalerite from the tailing of part G using copper sulphate to activate the sphalerite.

Flotation: Reasonably good separation of galena was obtained by using cyanide and zinc sulphate to depress the sphalerite flotation. One flotation made without zinc sulphate had a considerable sphalerite contamination in the galena, the separation appearing to be of such poor quality that no assays were made.

A reasonably satisfactory separation of sphalerite was obtained, not more than 5 pct of the sphalerite remaining in the tailing. When the sphalerite activation was accomplished with copper sulphate alone, that is, without calcium hydroxide, there was a large amount of quartz in the sphalerite concentrate, experiments 1S and 2S. This amount of quartz was reduced considerably by cleaning, but the amount remaining was still somewhat large, 30 g of total concentrate compared to 20 g obtained in the single flotations of sphalerite using copper sulphate. When calcium hydroxide was used with the copper sulphate, only a normal amount of quartz was floated.

Agreement in the weight of concentrate between experiments using radioactive and nonradioactive dithiophosphate was satisfactory.

Sorption: Radioactivity measurements could not be made for the galena tailing, since the tailing had to be used for the sphalerite flotation. A separate galena flotation therefore was carried out, experiment 5G, under similar flotation conditions to get radioactivity measurements for the galena tailing.

The results obtained in the selective flotations for the sorption of dithiophosphate and the concentration of dithiophosphate remaining in solution were in general agreement with the results obtained in single flotations. In the galena flotation without copper sulphate, the major part of the dithiophosphate remained in solution, and the sorption in the concentrate and tailing was typical of that found in the single flotations. In the sphalerite flotation using copper sulphate activation, only a relatively small amount of dithiophosphate remained in solution and considerably higher sorption values were obtained, again typical of that found in single flotations with copper sulphate activation. The single exception to

Table IV. Single Flotations with Copper Sulphate Activation, 0.12 Lb Per Ton of Di-(sec-butyl) Dithiophosphate (DTP), 0.5 Lb Per Ton of Copper Sulphate and 0.08 or 0.16 Lb Per Ton of Frother

	Reagents, Lb/Ton		Concentrate		Sorption of DTP, Mg/G		DTP in Filtrate: Concentration, Mg/Liter		DTP in Filtrate: Amt., Pct of Total
Ore	NaCN	Froth.	Wt, G	Pct of Total Pb$S or ZnS	Conc	Tail.	Conc	Tail.	
ZnS-SiO_2	—	0.08	16.6	99.6[a]					
	—	0.08	17.0		0.22	0.044	0.5	0.1	3.1
	—	0.08	17.3		0.24	0.031	0.6	0.2	2.5
	—	0.16	20.3		0.39	0.021	0.5	0.2	2.8
	0.10	0.16	19.2	99.0[a]					
	0.10	0.16	18.0		0.45	0.010	0.4	0.4	3.8
	0.10	0.16	18.9		0.92	0.006	0.5	0.5	3.9
SiO_2	—	0.08	—		—	0.022	0.3	0.1	—
	—	0.08	3.1		1.4	0.029	0.4	0.1	2.1
	0.10	0.08	3.2		0.90	0.031	0.8	0.3	4.0

[a] Nonradioactive experiments.

the general agreement was the result obtained in the sphalerite flotation at high alkalinity with the addition of calcium hydroxide, experiment 4S. A much larger part of the dithiophosphate remained in solution, 64 pct as compared to 13 pct when calcium hydroxide was not added.

It would have been of considerable interest to measure directly the sorption of dithiophosphate on quartz, galena, and sphalerite separately in the rougher concentrates. Attempts to separate the quartz from the galena or sphalerite were unsuccessful. Separation by flotation could not be used because dithiophosphate would desorb. A separation was achieved by gravity in acetylene tetrabromide, but it was found that dithiophosphate also desorbed in this medium. An attempted magnetic separation was likewise unsuccessful. However, an estimate of the sorptions on the separate minerals in the concentrate can be made. The sorption observed in experiments without copper sulphate on concentrates from the flotation of galena-quartz or sphalerite-quartz mixtures was in general agreement with the sorption on concentrates from the blank flotation with quartz alone. This indicates that the sorption per gram of mineral floated was about the same on all three minerals and is of some interest, since good separation was obtained with galena and poor separation with sphalerite. The sorption on the part of the sphalerite that does not float may be considerably lower. That is, flotation may take place whenever there is sufficient sorption of dithiophosphate, and only a part of the sphalerite may have sufficient sorption when no copper sulphate is present. An estimate could not be made of the separate sorptions on sphalerite and quartz in the tailings. It was calculated that, even if the sorption on the sphalerite in the tailing were as high as on the sphalerite in the concentrate, because of the preponderance of quartz there would have been no measurable increase in the overall sorption in the tailing.

It is of practical interest that only a small quantity of dithiophosphate is sorbed on the mineral surface in flotation, with a major part of the dithiophosphate remaining in solution. However, it should be noted that a relatively high concentration of dithiophosphate in solution may be required to get this small amount sorbed on the mineral.

The measured surface areas of a typical galena concentrate and a typical sphalerite concentrate were 4500 cm^2 per g as measured with a Fisher subsieve sizer. The calculated sorption of dithiophosphate on the concentrates was then 0.3 to 1.3 x 10^{-10} mol per cm^2 for both galena concentrates and sphalerite concentrates. The sorption was definitely lower than that calculated for a monolayer, 2.5 x 10^{-10} mol per cm^2 from Fischer-Hirschfelder models, showing that only part of the mineral surface needs to be covered for flotation in agreement with previous investigations.[1, 2]

The difference by a factor of ten or more in the observed sorption between the concentrate and tailings is believed sufficient to account for the difference in flotation. For example, it was previously found[2] in the flotation of galena alone (without quartz) with dithiophosphate that 10 pct of the galena was floated at 0.1 x 10^{-6} mol per g and nearly 100 pct floated at 1.0 x 10^{-6} mol per g.

Cyanide was shown to cause only a relatively small decrease in the sorption of dithiophosphate on the concentrates. The sorption on the sphalerite in the tailing could not be measured. It seems likely that the sorption on the sphalerite that does not float

Table V. Selective Flotations. Part G: Flotation of Galena, 1.0 Lb Per Ton $ZnSO_4$ and 0.1 Lb Per Ton NaCN with Reagents Listed. Part S: Flotation of Sphalerite, 0.5 Lb Per Ton $CuSO_4$ and 0.08 Lb Per Ton Frother with Reagents Listed

	Reagents, Lb/Ton		Concentrate			Sorption of DTP, Mg/G		DTP in Filtrate: Concentration, Mg/Liter		DTP in Filtrate: Amt., Pct of Total
				Pct of Total						
Exp. No.	DTP	$Ca(OH)_2$	Wt, G	PbS	ZnS	Conc	Tail.	Conc	Tail.	
1G	0.09		18.6	97.8[a]	20.6					
1S	0.12		91.2[b]	1.9[a]	79.4					
2G	0.09		20.2			0.10	—	0.1	—	
2S	0.12		40.4[b]			0.27	0.035	1.2	0.7	13.1
3G	0.09		14.8	93.0[a]	13.7					
3S	0.12	1.0	18.2	96.0[a]	82.0					
4G	0.09		17.3			0.13	—	0.7	—	
4S	0.12	1.0	15.5			0.29	0.010	13.0	7.8	64.1
5G	0.09		16.2			0.19	0.004	7.8	4.7	62.4

[a] Nonradioactive experiments.
[b] Weight of cleaner concentrate was about 30 g.

is considerably lower, but the experiments do not provide any way of proving this point.

Since copper dithiophosphate is a compound of low solubility, it appeared likely that the low dithiophosphate concentrations in solution when copper sulphate was present resulted from bulk precipitation of copper dithiophosphate. Dithiophosphate was added to a solution of copper sulphate using the same concentrations as in the flotation experiments but without the minerals and other reagents. A visible precipitate formed. Filtering through a sintered glass filter a few hours after precipitation left only 14 pct of the dithiophosphate in solution, some of which may have been unfiltered solids. This strongly indicates that copper dithiophosphate was precipitated in the flotation experiments. The marked increase in the measured sorption of dithiophosphate was probably caused in large measure by the inclusion of precipitated copper dithiophosphate by the minerals. However, an actual sorption of some copper and dithiophosphate must also have occurred on the surface of the mineral. Recent work by Gaudin et al[4] has shown that, in the absence of a collector, copper is sorbed by sphalerite to a limiting amount of approximately 1 monolayer. Any mineral-dithiophosphate interaction in the presence of copper sulphate would have been masked, in the present work, by the precipitation of copper dithiophosphate.

The selective flotations at high alkalinity using lime with the copper sulphate did not appear to involve the bulk precipitation of copper dithiophosphate. This is seen most obviously by comparing the solution concentrations of experiment 4S (pH 10.8) with experiment 2S (pH 6.8). In experiment 4S, a considerable portion of the dithiophosphate remained in solution. One might assume that in the alkaline solution copper was precipitated as a basic salt, leaving the dithiophosphate unprecipitated, as has been suggested by Wark.[5]

It may be suggested that the quartz which sorbed dithiophosphate and floated was activated by metal ions present, as, for example, in the flotation of quartz with a fatty acid collector studied by Schuhmann and Prakash.[6] The reason was not established for the unusually large amount of quartz floated with the sphalerite in the selective flotation without lime as compared with the smaller amount floated in the single flotation of sphalerite alone from quartz. The differences in the experimental conditions in the two flotations were that in the selective flotation zinc sulphate was present, dithiophosphate was present before the copper sulphate activation as well as after, and a shorter period of conditioning with dithiophosphate was used. In practice, the sphalerite flotation is generally carried out under alkaline conditions so that the quartz flotation will be depressed.

Summary

Previous radiotracer studies[1,2] of the interaction of a dithiophosphate collector with galena have been extended by a study of the distribution of dithiophosphate during the selective flotation of galena and sphalerite from quartz in a Fagergren machine using sodium cyanide to depress and copper sulphate to reactivate the sphalerite. By tagging dithiophosphate with radiosulphur, the amount of dithiophosphate taken up by the mineral concentrates and tailings and the amount remaining in solution could be easily determined. The single flotations of galena from quartz and sphalerite from quartz were studied in addition to the selective flotation of the three minerals.

When no copper sulphate was added, only a small part of the dithiophosphate was taken up by the mineral, about 80 pct of the added dithiophosphate remaining in solution. There was at least ten times more dithiophosphate sorbed on the concentrates than on the tailings. The amounts sorbed on the galena, sphalerite and quartz in the concentrates appeared to be approximately equal, and to correspond to less than a monolayer on the mineral surfaces.

When copper sulphate was added, the measured amounts of dithiophosphate in the concentrate and tailing increased by about tenfold. However, since there is evidence that copper dithiophosphate precipitated, these values are not believed representative of the amounts active in flotation. Using copper sulphate in a highly alkaline medium, a much larger amount of dithiophosphate remained in solution, apparently because dithiophosphate was not precipitated.

The addition of cyanide, which does not depress the flotation of galena, caused at most a small decrease in the sorption of dithiophosphate on the galena concentrate. In floating sphalerite, where the flotation is strongly depressed by cyanide, it was not possible to determine experimentally the sorption on the portion of the sphalerite which did not float, because of the preponderance of quartz in the tailing. On the small amount which did float, there appeared to have been a slight decrease in sorption, comparable to that observed for the galena concentrate.

These results were obtained under conditions more closely approximating conditions of actual practice than heretofore. The results support former beliefs that a relatively small amount of collector need be sorbed on the mineral for its flotation. The use of a considerably larger quantity of collector in solution may nevertheless be necessary to get this small amount onto the mineral surface.

Acknowledgment

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Chemicals From Coal Hydrogenation

by E. E. Donath

Application of the coal hydrogenation process for the production of chemicals is described. It has been estimated that a plant to produce 31,090 bbl per day of chemicals and fuels would cost $326,000,000. These products would consist of 6.1 pct by weight tar acids, 50.8 pct aromatics, 16.4 pct LPG, and 26.7 pct gasoline.

THE coal hydrogenation process is well known as a means for the production of liquid fuels from coal. In this paper the possibilities of the coal hydrogenation process as a source of chemical raw materials will be discussed. The recovery of chemicals from coal hydrogenation products necessitates some modifications and additions to the equipment used for the production of fuels. The conversion of coal into liquid fuels such as gasoline requires two steps: liquid phase and vapor phase hydrogenation. Intermediate oils obtained in the liquid phase contain oxygen and nitrogen compounds, especially aromatic compounds, since the coal itself is composed mainly of cyclic compounds. These oils are the raw material for the separation of high molecular weight aromatics and of tar acids and tar bases. The relative amounts of heavy and middle oil—boiling above and below, e.g., 325°C—can be influenced by temperature, residence time, and catalyst of the liquid phase hydrogenation. In the vapor phase hydrogenation a solid bed catalyst is used to convert the intermediate oil from the liquid phase operation into hydrocarbons of the gasoline boiling range. Essentially pure hydrocarbons with a low content of sulphur, oxygen, nitrogen, and olefines are obtained. Depending mainly on the catalyst, the high ring compound content of the liquid phase oil can be preserved and gasoline rich in aromatics obtained. However, with other catalysts, these ring compounds can be split into gasoline with a high content of isoparaffins.[1] Again, depending on the operating conditions, products of varying boiling range can be obtained. Selection of catalyst and operating conditions therefore makes possible the production of different grades of motor fuel and also variations in the relative amounts of benzene, toluene, and xylene when aromatic hydrocarbons are produced.

The schematic flowsheet, Fig. 1, shows the main steps of the coal hydrogenation process, and the product streams used for the recovery of chemicals are indicated. In the liquid phase hydrogenation stage, coal is made into a paste with recycle heavy oil. The coal paste is mixed with hydrogen and preheated at a pressure of 300 to 700 atm in heat exchangers and preheaters. The coal paste and hydrogen enter high pressure converters where the liquefaction of coal, conversion of the high boiling liquid materials initially obtained, into intermediate oils is performed at a temperature around 470°C. The reaction products enter the hot catchpot in which lower boiling oil vapors are separated from the residue containing unreacted coal, ash, and heavy oil. This residue, usually called H.O.L.D. (heavy oil let down), is processed to separate solid and liquid material. By thermal treatment of the residue, e.g., a coking process, distillate oil is obtained, which can be recycled as part of the pasting oil. This stream is rich in polynuclear aromatics and can be, and has been, used for the recovery of such material.

The oil vapors and hydrogen from the hot catchpot are cooled in heat exchangers and a cooler, and the condensed oil is separated from the recycle hy-

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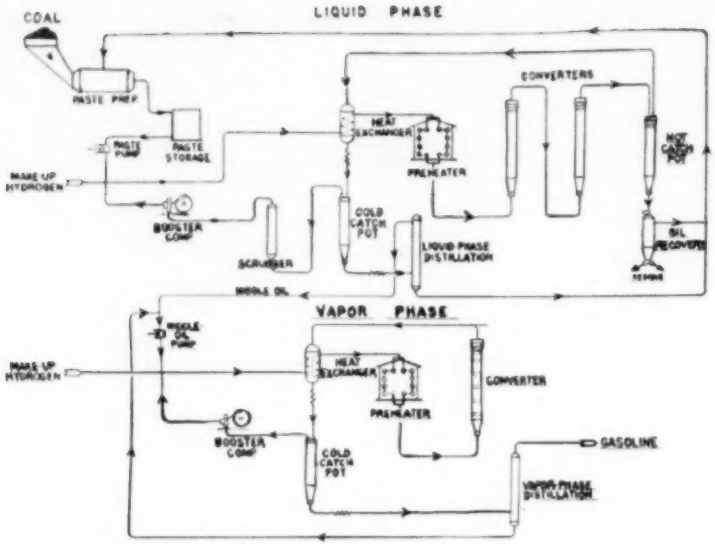

Fig. 1—Coal hydrogenation.

drogen. The oil condensed in the cold catchpot is depressured and separated from dissolved gases. It passes to the liquid phase distillation facilities and is separated into an overhead stream, usually boiling below 325°C, and bottom oils, which are recycled as pasting oil. The overhead stream, or middle oil, is the fresh feed to the vapor phase hydrogenation stage where it is converted into gasoline. Because of its content of tar acids and tar bases, this middle oil is the main source of these compounds.

After the separation of tar acids, this middle oil is converted in the vapor phase, with a fuller's earth-molybdenum catalyst, into gasoline with a high content of ring compounds. The gasoline is the raw material for the production of aromatic hydrocarbons. Benzene, toluene, xylene, and higher aromatics can be separated from this gasoline by extraction with selective solvents or by extractive distillation. Additional aromatics can be obtained from the naphthenes by dehydrogenation using Hydroforming, Platforming, or similar processes.

During coal hydrogenation the nitrogen and sulphur contained in the coal react with hydrogen. The nitrogen and sulphur content of the coal is recovered as ammonia and hydrogen sulphide from off-gases and aqueous effluents. Hydrogen sulphide is converted by conventional processes into sulphur or sulphuric acid. Both sulphur and ammonia at present are in short supply.

Coal and coal hydrogenation products are compounds of carbon and hydrogen with minor proportions of oxygen, nitrogen, and sulphur. The reactions that occur during the coal hydrogenation process are indicated to some extent by the average molecular weight of the products obtained and the ultimate composition expressed in atoms of hydrogen, oxygen, nitrogen, and sulphur per atom of carbon, Table I.

The general trend, as the molecular weight decreases, is an increase in hydrogen and a decrease in oxygen, nitrogen, and sulphur content. One exception is the coker distillate which, because of the thermal treatment without hydrogen, shows a decrease in hydrogen content in comparison with the residual heavy oil from which it is obtained. This coker distillate, therefore, contains polynuclear aromatics. Another exception is the middle oil with a higher oxygen content indicating the presence of tar acids.

The position of coal and coal hydrogenation products in comparison to hydrocarbons of known com-

Table I. Atomic Composition of Coal and Coal Hydrogenation Products

	Molecular wt, Avg	Carbon-Atoms per Molecule, Avg	Atoms per Atom Carbon			
			H	O	N	S
Coal	(800)	(60)	0.75	0.1	0.02	0.01
Residual heavy oil	400	30	0.9	0.01	0.01	0.00
Coker distillate	300	25	0.8	0.02	0.01	0.00
Distillate heavy oil	300	23	1.1	0.01	0.01	0.00
Middle oil	200	15	1.3	0.03	0.01	0.00
Gasoline	100	7	1.8	0.00	0.00	0.00

Table II. Liquid Phase Middle Oil from Wyoming Bituminous Coal, Pct

Total tar acids	17
Tar bases	4
Separated tar acids:	
Phenol	1.66
o-Cresol	0.50
m-p-Cresol	2.44
Xylenols	1.93
C_{9+} tar acids	6.53
Sulphur content of C_{9+} tar acids	0.03-0.05

position can be seen in Fig. 2 in a diagram according to Van Krevelen.[3] In this diagram the atomic hydrogen to carbon ratio is plotted against the number of carbon atoms per hydrocarbon molecule for different hydrocarbon series. The hydrogen content of coal and heavy oils indicates that they are mainly aromatic compounds. The hydrogen content of middle oil and of gasoline indicates that they contain saturated hydrocarbons in addition to aromatics.

The general nature of the coal hydrogenation products as indicated by the ultimate analysis is borne out by the individual compounds which have been identified or separated. As in other mixtures, e.g., coal tar or petroleum, especially in the high boiling fractions, only part of the compounds can be identified. Condensed aromatic rings were identified in the heavy oil fractions. From coker distillate compounds have been separated in pure form.[4] Aromatics from coker oil are as follows: carbazole, 1 pct; pyrene, 8 to 10 pct; pyrene homologues, 1 to 2 pct; benzperylene, 0.1 pct; and coronene, 0.5 to 1 pct.

The normal method for the separation of these compounds is combined distillation and crystallization. Besides carbazole, other high molecular weight nitrogen bases and tar acids have been recovered from heavy oil, although individual compounds have not been identified.

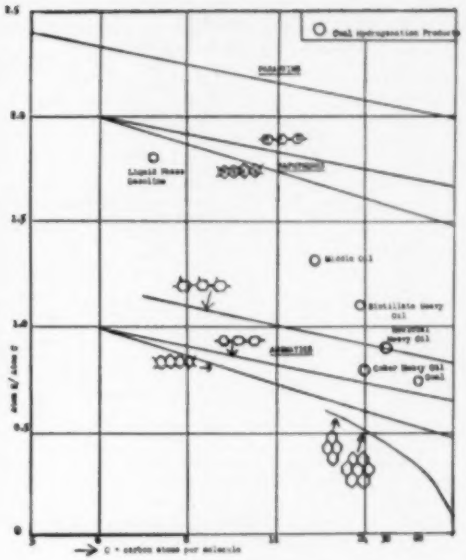

Fig. 2—H/C ratio of hydrocarbons and coal hydrogenation products.

Table III. Gasoline Composition

	Naphthenes, Pct	Aromatics, Pct	Total Ring Compounds
Coal hydrogenation gasolines			
Liquid phase	32	37	69
Vapor phase, fuller's earth catalyst	38	40	78
Vapor phase, tungsten sulphide catalyst	50	5	55
Straight run gasolines			
Midcontinent crude oil	35	2	37
Gulf coast crude oil	52	2	54

The liquid phase middle oil is the raw material for the recovery of tar acids. An investigation of the tar acids contained in coal hydrogenation oil from Pittsburgh bed coal has been made at the Bureau of Mines Station in Bruceton[4] and 16 individual phenols have been identified. The tar acid content of coal hydrogenation middle oils boiling below 325°C is 15 to 25 pct. The middle oil fraction boiling from 160 to 225°C contains about 30 pct commercially useful tar acids from phenol to xylenol. Tar acids* separated from liquid phase middle oil from hydrogenation of Rock Springs Wyoming coal in the U. S. Bureau of Mines demonstration plant at Louisiana, Mo., are shown in Table II. This middle oil had a total tar acid content of 17 pct and also contained 4 pct tar bases. The phenol, cresol, and xylenol, the commercially important tar acids, amount to 6.53 pct of the middle oil. The sulphur content of these tar acids from coal hydrogenation is about 0.03 to 0.05 pct, which is similar to the sulphur content of tar acids from coke oven tar.

Gasolines from coal hydrogenation as indicated by the hydrocarbon ratio are rich in ring compounds. This is confirmed by actual hydrocarbon group analyses shown in Table III. Liquid phase gasoline contains about 69 pct total ring compounds and vapor phase gasoline obtained with fuller's earth catalyst about 78 pct. The ring compound content of a gasoline obtained with tungsten sulphide catalyst is only 55 pct. For the production of low boiling aromatic hydrocarbons such fuller's earth catalysts would be used. In comparison, straight run gasolines from midcontinent crude oil contain only 37 pct and from Gulf coast crude oil 54 pct ring compounds, and the aromatic content is small. Since naphthene rings can be converted readily into aromatics, the coal hydrogenation gasolines because of their high content of aromatics and total ring compounds give a higher yield of benzene, toluene, xylene, and other aromatics than straight run gasolines obtained from petroleum, which at present are used for the production of aromatics. The ratio of the individual aromatics can be changed within wide limits in the boiling range of gasoline. By using lower throughput, higher temperature or higher recycle ratio in the vapor phase hydrogenation, the percentage of benzene, e.g., can be increased at the cost of higher boiling aromatics. The aromatics are pure, sulphur-free compounds; benzene and toluene are of nitration grade. The xylene fraction obtained from German bituminous coal contained about 30 pct ortho-, 25 pct meta-, 15 pct para-xylene and 30 pct ethylbenzene.

A more detailed analysis of some of the cyclic compounds that were identified in the 50 to 150°C fraction of vapor phase gasoline from Wyoming coal[5] with an activated fuller's earth catalyst is given in Table IV. The gasoline fraction in addition to 5.9 pct benzene present as such contains 12.2 pct methylcyclopentane and cyclohexane, which can be converted into benzene. It might be mentioned that with other catalysts different amounts of aromatics

* According to analyses by R. S. Detrick, J. Beaumont, P. M. Salinger and W. M. Lee, Mellon Institute and Koppers Co., Inc., Pittsburgh, Pa., under terms of the cooperative agreement between U.S. Bureau of Mines, Demonstration Branch, Louisiana, Missouri and Koppers Co., Inc., Pittsburgh, Pa.

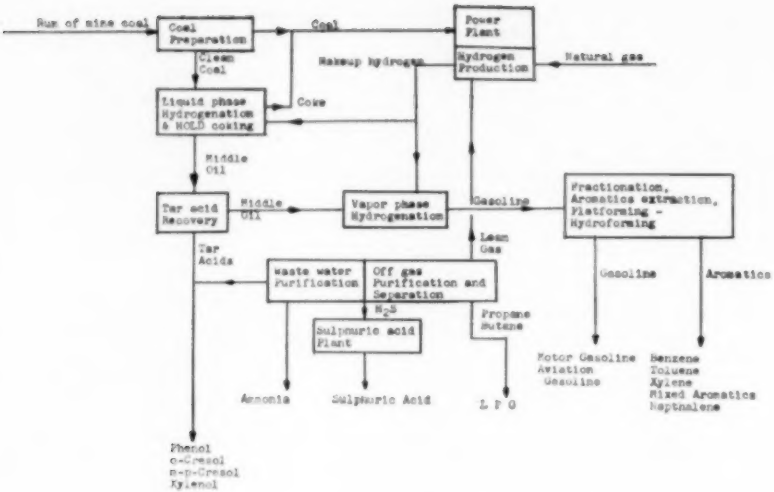

Fig. 3—Coal hydrogenation plant for production of chemicals and fuels.

can be obtained as well as a different distribution between five and six number ring naphthenes.

In the preceding paragraphs the general types of chemicals that can be obtained by coal hydrogenation have been described. It has been shown that coal hydrogenation products are a very suitable raw material, especially for chemicals of the aromatic series. These chemicals are not only in short supply today, but a rapidly increasing demand is anticipated in the future. Data for an integrated plant for the production of chemicals will now be given.

A plant for the production of about 30,000 bbl per day of products has been assumed. Economic studies have indicated that a plant of this size shows marked decrease in plant and operating cost per unit over plants of 10 to 15,000 bbl per day capacity. Such a plant, in addition to facilities for the manufacture of hydrogen and the power plant and auxiliary facilities, would contain the main processing units shown in the block diagram, Fig. 3. Use of Illinois coal from No. 6 bed has been assumed. In the coal preparation plant, run-of-mine coal is separated in a heavy media cleaning plant into clean coal for the hydrogenation plant, middlings for the power plant, and refuse. The clean coal is dried, ground, and after addition of iron catalyst, is made into a paste with recycle heavy oil for injection into the liquid phase unit. Liquid phase hydrogenation at 700 atm pressure and 480°C combined with H.O.L.D. coking convert the coal into middle oil and separate the recycle pasting oil from solid residue. Tar acids, phenol, cresols, and xylenols are obtained from the middle oil by fractionation and extraction. The remaining middle oil is converted into gasoline in the vapor phase hydrogenation unit using an activated fuller's earth catalyst at 700 atm pressure and 500°C. From the gasoline, hydrocarbons with less than six carbon atoms are separated as light ends, and from the higher fractions, the aromatics are separated by a combined treatment with extraction, Platforming and Hydroforming processes. Benzene, toluene, xylenes, mixed aromatics, and naphthalene are obtained. The nonaromatic fractions and some of the aromatics are blended into motor and aviation gasoline.

Hydrogen sulphide is removed with ethanolamine from off-gases from liquid and vapor phase, coking, and hydroforming units. The off-gas is separated further into lean gas, containing mainly hydrogen, methane and ethane used for hydrogen production and LPG, containing propane and butane. From the aqueous effluent tar acids are extracted and ammonia and hydrogen sulphide separated. Hydrogen sulphide from waste water and off-gas is converted into sulphuric acid.

Table IV. Vapor Phase Gasoline from Wyoming Coal, Fraction 50 to 150°C

	Weight Pct	
Naphthenes:		
Methylcyclopentane	8.6	12.2
Cyclohexane	3.6	
Dimethylcyclopentane	8.0	17.1
Ethylcyclopentane	2.9	
Methylcyclohexane	6.2	
C_8-naphthenes	13.3	
	42.6	
Aromatics:		
Benzene	5.9	
Toluene	11.2	
C_8-Aromatics	10.4	
	27.5	

Table V. Plant Cost—30,000 Bbl Per Day Coal Hydrogenation Plant

	Million $
Coal handling and preparation	9.3
Liquid phase hydrogenation and coking unit	67.0
Tar acid recovery and purification	5.0
Vapor phase hydrogenation	32.5
Aromatics production and separation	31.5
Off-gas and waste water purification and disposal and LPG recovery	14.3
Sulphuric acid and ammonium sulphate plant	4.5
Hydrogen production	66.0
Power plant	54.5
General facilities and utilities and tankage	51.4
Total plant cost	336.0

The hydrogen required is produced by steam splitting of lean gas and natural gas because of low plant and operating costs. If natural gas should not be available, hydrogen would be produced from off-gas and coal.

The main raw materials for the production of 30,000 bbl per day chemicals and liquid fuels are 16,000 tons per day of run-of-mine coal of 11,000 Btu per lb heating value for process and power plant coal, and 83 million cu ft per day of natural gas for hydrogen production. Plant costs of $326 million, corresponding to $10,500 per daily barrel of products, have been estimated as indicated in Table V. These costs do not include cost of the plant site, mine development, interest during erection, starting up expense, and operating capital.

Products obtainable are listed in Table VI. The tar acids amount to 6.1 pct by weight, the aromatics to 50.8 pct of total products. The ammonium sulphate and sulphuric acid production is shown separately. LPG which can be used as fuel, as well as chemical raw material, is 16.4 pct of the total. Motor and aviation gasoline, 15.6 and 11.1 pct respectively, amount to 26.7 pct of the total products. The value of these products per year, at present market prices, is $135 million, about 40 pct of the aforementioned plant cost.

Gasoline, LPG, ammonia, and sulphuric acid from such a plant amount to only 0.2 to 2 pct of the present production of the United States. The contribution of the aromatics and tar acids produced to United States production of these materials, however, would be substantial, as indicated by Table VII. The tar acids produced in such a plant are equivalent to 50 pct of the 1950 production, while the aromatics are equivalent to 54 pct. Benzene and phenol are the two chemicals in this group that are produced in greatest quantity in the United States. The contribution of a 30,000 bbl per day plant would be equivalent to 18 pct of the present benzene and 17 pct of the present phenol production. The 1950 production data for toluene and xylene are only for that portion of these chemicals that is produced in pure form. Considerable additional amounts are used in the form of solvents and motor fuel. At present these materials tend to be in short supply, and large quantities of tar acids and benzene are imported in addition to the production recorded in Table VII. The demand for tar acids and aromatics in the plastic, synthetic fiber and other industries is increasing rapidly, and, therefore, no overproduction is anticipated. If erection of such a plant were started now, operation could not begin in less than 3 years. It should be mentioned that the proportions of the various chemicals produced can be influenced by the selection of operating conditions.

It has been shown that the products from such a coal hydrogenation plant would mean a substantial contribution to the production of chemicals now in short supply and for which the demand is rapidly increasing. In addition, such a plant would make available know-how and experience for the erection and operation of coal hydrogenation plants for the production of synthetic liquid fuels when they are needed in the future to supplement petroleum production.

Table VI. Chemicals and Fuels Production, 30,000 Bbl Per Day Coal Hydrogenation Plant

	Lb per Day	Bbl per Day	Tons per Day	Wt Pct of Total Product
Tar Acids				
Phenol	157,400	428		1.9
o-Cresol	17,600	48		0.2
m-p-Cresol	192,000	530		2.4
Xylenols	136,000	374		1.6
	503,000	1,380		6.1
Aromatics				
Benzene		2,210		8.2
Toluene		3,770		13.9
Xylenes		4,100		13.4
Mixed aromatics		1,780		6.8
Ethylbenzene		730		2.8
Naphthalene	316,000	790		3.7
		13,490		50.8
LPG		7,300		16.4
Gasoline				
Motor gasoline		5,260		15.6
Aviation gasoline		3,660		11.1
		8,920		26.7
Total		31,090		100.0
Ammonium sulphate			450	
Sulphuric acid			80	

Table VII. Chemicals from 30,000 Bbl Per Day Coal Hydrogenation Plant in Comparison to 1950 U. S. Production

	1950 Production, Million Lb	1950 Production, Million Gal	Products from 30,000 Bbl/Day Plant as Pct of 1950 Production
Tar Acids			
Phenol	312		18
Cresols	19		400
Xylenols, cresylic acid	37		135
	368		50
Aromatics			
Benzene		300	17
Toluene		94	69
Xylene		72	89
Mixed aromatics			
Ethylbenzene		(80 estimated)	14
Naphthalene, 290 million lb		(30)	40
Aromatics		386	54

Acknowledgment

The writer wishes to acknowledge contributions and helpful suggestions by W. E. Simmat, Koppers Co., Inc., Pittsburgh, Pa.

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Some Dynamic Phenomena in Flotation

by W. Philippoff

ALTHOUGH Gaudin[1] and more recently Sutherland[2] have calculated the probability of collision of a falling mineral particle with a rising bubble, there is no published information concerning the details of the mechanism of attachment of a collector-coated particle to a bubble. During the past year the writer has developed a theory for the mechanism of attachment, which has been substantiated experimentally. Funds for the investigation and for some of the equipment used have been supplied by the Mines Experiment Station of the University of Minnesota.

Motion picture studies of the phenomena involved in the collision between mineral particles and bubbles, such as those of Spedden and Hannan,[3] show that the contact can be completed within 0.3 millisec. Formulas developed for rigid bodies have hitherto been used[4] for the calculation of the motion of bubble and particle, but it is obvious that a bubble cannot be regarded as a rigid body. On the contrary, Spedden and Hannan's pictures show a great degree of deformation during the collision. The time of attachment was calculated as the time the particle drifted past the bubble.

Time of Collision

The theory presented in this paper enables calculation of the time of collision, using the concept that the bubble, or more generally, a liquid-air interface, acts as an elastic body. The elasticity, defined as the restoring force on a mechanical deformation, is caused by the surface tension and is the result of the principle of the minimum of free surface energy. It is well known that an elasticity together with a mass determines a frequency of vibration. The vibrations of jets and drops caused by the elasticity of the interface are known to comply exactly with the classical theory of capillarity.[5] However, the vibrations of isolated bubbles, as distinct from foams, have not been investigated previously. The following equation, presented elsewhere,[6] has been deduced for these frequencies:

$$f_n = 9.20 \cdot \sqrt[3]{V} \cdot \sqrt{n \cdot (n-1) \cdot (n+2)/8} \qquad [1]$$

in which f_n is the frequency of a harmonic of the bubble in cycles per second, V the volume of the bubble in cc, n a number determining the order of the harmonic, and $n = 2$ the basic vibration. The first (basic) harmonic describes a change of the spherical bubble to an ellipsoidal bubble. The higher harmonics are more complicated, for the circumference of the bubble is divided approximately into as many parts as the order of the harmonic. As an example, Spedden and Hannan's published motion picture of a vibrating bubble corresponds to the sixth harmonic. Eq 1 shows that only the first and third harmonics are simple multiples (1 and 3), all the others being irrational fractions of the basic frequency. This means that the shape of the vibration can change with time and is in general unsymmetric in respect to the time axis. Such conditions prevail when there is a distributed elasticity or mass, as in the case of vibrating membranes or rods. The constant 9.20 is valid for water at room temperature, but a general solution involving the physical constants of the liquid has not been found.

The case of the floating particle is much easier to treat than that of the bubble. It can be assumed that the elasticity is caused exclusively by the interface and that the mass is concentrated in the particle together with some adhering water. The following expression for the frequency of a system of one degree of freedom can be applied:

$$f_p = \frac{1}{2\pi}\sqrt{E/m} \qquad [2]$$

Here f_p is the frequency of the particle vibration in cycles per second, E the elasticity in dynes per cm, and m the mass in grams. The classical theory of impact phenomena gives the time of collision during the striking of a spring (in this case the surface of the bubble) by a mass, as:

$$t_c = 2/f = \pi\sqrt{m/E} \qquad [3]$$

It is now possible to develop an expression for the elasticity of a floating cylindrical particle. The force equilibrium of a cylinder floating end on at the air-liquid interface is given by the well-known equation (Poisson[7] 1831)

$$P = \frac{\pi}{4} D^2 \cdot \rho_L \cdot g \cdot h + \pi D \cdot \gamma \sin \alpha \qquad [4]$$

which accounts for the buoyancy *and* the action of the surface tension where P is the force acting on the particle in dynes (weight-buoyancy), D the diameter of the cylinder in cm, ρ_L the density of the liquid in grams per cc, g the acceleration of gravity = 981 cm per sec^2, h the depression of the cylinder below the surface of the liquid in cm, γ the surface tension in dynes per cm and α the supporting angle[8] or the one required to insure equilibrium, α being smaller than the contact angle θ.

Although demonstrated by Poisson, it has not

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been pointed out since that h and a are interrelated. Introducing the Laplace constant a:

$$a = \sqrt{2\gamma/g \cdot \rho_L} = 3.85 \text{ mm for water} \qquad [5]$$

the relation for particles the diameter of which is small compared with a is:

$$h = (D \cdot \sin \alpha)/2[\ln(a/D) + 0.46251] \qquad [6]$$

Inserting this relation into eq 4, simplifying, and as the elasticity $E = P/h$, the following expression is obtained for E, see Fig. 1:

$$E = 2\pi\gamma\,[D^2/4a^2 + 1/\{\ln(a/D) + 0.46251\}] \qquad [7]$$

or for the sake of simplicity:

$$E = 2\pi\gamma \cdot \phi^2 \qquad [8]$$

where ϕ^2 is the expression in brackets, depending only on the ratio D/a. In Table I this function is tabulated for the range of particle sizes important in flotation. Having now calculated E, eq 8 is introduced in eq 3, and the following expression for the time of contact (t_c) is obtained:

$$t_c = \sqrt{\frac{2\pi}{\gamma}} \cdot \sqrt{m}/\phi = 4.67\sqrt{m}/\phi \qquad [9]$$

In the simplified expression t_c is in milliseconds and m in milligrams, convenient units for the particle size-range investigated, the value being calculated for water ($\gamma = 72$ dynes/cm).

It must be stated that a direct contact of the surfaces of the cylinder and the bubble is not needed to cause a deformation of the bubble, i.e., the elasticity is present also with a layer of water between them. This layer of water is being pressed out during contact, as will be seen.

Eq 9 can be evaluated by using arbitrarily a particle of a height equal to its diameter, somewhat like a cube, with a density of 7.5. The results are given in Table I. Under the assumed geometric conditions the time of contact t_c is proportional to $D^{1.5}/\phi$. The calculated times are little dependent on the shape of the particle, for the function ϕ as seen from Table I varies only about 1 to 3 in a range of particle sizes of 1 to 20000. Of course, as has been mentioned, the actual mass is somewhat larger than that of the particle. The calculated times are comparable to the time of 0.3 millisec, measured by Spedden and Hannan. Wolkowa[4] calculated t_c approximately as (diameter of the bubble)/(velocity of the bubble) to 5 and 10 millisec independent of the diameter of the particle.

These considerations show clearly that the attachment of a mineral particle to a bubble is necessarily extremely fast, otherwise the particle will tend to jump off the surface of the bubble after t_c has elapsed. This has actually been observed by Spedden and Hannan. The high-speed phenomenon of attachment requires special equipment hitherto not used to analyze it and would make any long-time phenomena such as the *induction time* of Sven-Nilsson[5] questionable as to their influence on the mechanism of attachment.

Table I. Times of Contact (t_c) and the Required Velocities of Film Recedence (v_r)

Diam of Particle, (D), Microns	Function, ϕ	Time (t_c), Millisec	Velocity (v_r) Cm per Sec
1000	0.741	15.3	3.27
500	0.635	6.33	3.95
200	0.541	1.88	5.32
100	0.4925	0.74	6.75
50	0.4580	0.28	8.90
20	0.4185	0.077	13.00
10	0.3935	0.029	17.2
5	0.3750	0.0117	21.4
2	0.3522	0.0029	34.5
1	0.3390	0.0011	45.4

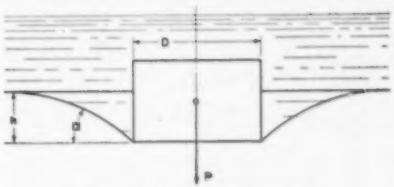

Fig. 1—Equilibrium at the bubble surface.

Film-Recedence Velocity

Assuming a radial recedence, an approximation of the velocity with which a liquid film should recede after being punctured in the center to form a mineral-air interface during the time t_c is simply:

$$v_r = D/2t_c \qquad [10]$$

The calculated velocities are listed in Table I.

The next step is the calculation of the velocity of the film-recedence, which should at least equal v_r. This necessitates the calculation of the thickness of the liquid film δ between the flat face of the cylindrical particle and the assumed flat bubble surface.

Stefan's equation[10] gives the dependence of the time t and the force P for the case of two circular planes moving towards each other:

$$t = (3\pi\eta\, D^4/64P) \cdot (1/H_1^2 - 1/H_2^2) \qquad [11]$$

in which η is the viscosity of the liquid in poises and H_1 and H_2 the final and initial film thicknesses in cm. Assuming a particle coming from infinity: $1/H_2 = O$ and $H_1 = \delta$, where δ is the required film thickness. This gives:

$$P \cdot t = (3\pi/64)\ \eta\ D^4/\delta^2 \qquad [12]$$

Applying the law of impulse:

$$P \cdot t = \epsilon m \cdot v$$

where ϵ is the change of the velocity of the particle before and after the impact. Assuming a large bubble hitting a small particle, it is necessary to consider only the mass of the particle. Likewise the Stokes' velocity of the particle can be disregarded compared with the rising velocity of the bubble v_b. It is not difficult to obtain a closer approximation. The final expression is:

$$\delta = D^2/8\sqrt{3\pi\eta/\epsilon \cdot v_b \cdot M} \qquad [14]$$

This mode of calculation has been used by Eirich and Tabor[11] for a hammer striking an anvil under a liquid. The film thicknesses δ, evaluated according to eq 14, are listed in Table II.

The case of a fluid receding under the influence of surface tension on a hydrophobic surface has never been visualized and therefore not treated. If a thin film of liquid on a solid, the system having a finite contact angle θ, is pierced centrally, the film will recede radially, the decrease in free surface energy being converted into kinetic energy of the receding

Table II. Minimum Film Thicknesses During Collision

Diam of Particle, D, Microns	Film Thickness, δ, Microns	δ/D
1000	9.8	0.010
500	6.9	0.014
300	4.4	0.022
100	3.1	0.031
50	2.2	0.044
20	1.4	0.070
10	1.0	0.10
5	0.7	0.14
2	0.44	0.22
1	0.31	0.31
0.5	0.22	0.44
0.2	0.14	0.70
0.1	0.10	1.00

film. This concept has been used by Boys[17] to calculate the bursting velocity of a bubble. The diameter of the initial central break has to be larger than the one determined by eq 6 when α equals θ. This is the criterion for the film stability. The driving force is obviously the surface tension, which acts at the angle α to the surface, whereas the equilibrium value is θ. This velocity, which is independent of the radius, is computed according to:

$$v = D/2t = \sin\theta/2 \sqrt{\frac{4\gamma}{\delta\rho_L}} = 17 \cdot \sin\theta/2 \cdot 1/\sqrt{\delta} \quad [15]$$

The second expression is for water with $\gamma = 72$ dynes/cm.

Contact Angle

Having now established the basic relations, it is possible to calculate the contact angle θ that would, under the assumed somewhat idealized conditions, be necessary to enable a contact to be established during the time t_c. For this purpose the velocity v_r from eqs 9 and 10 is made equal to the velocity from eq 15 using eq 14, and the following expression for the minimum necessary contact angle is obtained:

$$\sin\theta/2 = \phi/8\pi \sqrt[4]{\frac{3\eta\rho_L{}^2}{\epsilon V_B \cdot \rho_P{}^2}} (D/L)^{\circ} 1/\sqrt[4]{D} \quad [16]$$

Putting the viscosity of water $\eta = 0.01$ poises, the velocity of the rising bubble $v_B = 30$ cm per sec, $\epsilon = 1$, the particle density $\rho_P = 7.5$, the water density $\rho_L = 1$ and $D/L = 1$ the final expression is obtained in which D is in microns:

$$\sin\theta/2 = 1/(22.7\sqrt[4]{D}) \quad [17]$$

The evaluation of eq 17 is given in Table III, together with the minimum equilibrium contact angles computed from eq 4. Both values are of the same order of magnitude for the larger particles, but the equilibrium values fall off with D^2, whereas the dynamic values calculated from eq 17 tend to assume higher values for smaller particles. This relation is important in regard to the possible connection of the phenomena considered with the known difficulty of flotation of fine particles or slimes. Both values of θ however are far smaller than those usually accepted as necessary for flotation, especially if one considers that $(1-\cos\theta)$ falls off exceedingly fast at small angles. It is improbable that an air-mineral interface could be destroyed after contact is established as then not the small contact angle, α, calculated but the maximum possible one has to be overcome. Of course these calculations must be supplemented by the deductions of Gaudin and of Sutherland to give the actual decrease in flotability of fine particles due to the decreased probability of collision.

Table III. Minimum Necessary Contact Angles

Diam of Particle, D, Microns	Sin θ/2 Dynamic	θ Dynamic, Deg	θ Static, Deg
1000	0.00583	0.675	12.0
500	0.00590	0.675	3.10
200	0.00634	0.728	0.50
100	0.00687	0.787	0.13
50	0.00755	0.865	0.032
20	0.00874	1.000	0.0050
10	0.00978	1.121	0.0013
5	0.01100	1.265	0.00032
2	0.01309	1.500	0.000050
1	0.01495	1.715	0.000013

If account is to be taken of the centrifugal force in the flotation cell, the equilibrium values should be multiplied by the assumed number of g's increasing them accordingly. The dynamic values will also be diminished, especially the relative velocity v_B of bubble and particle. But this does not affect the general picture. An increase in acceleration increases ρ_P and v_B. The time of contact t_c in eq 3 is independent of the acceleration.

The values for the dynamic θ also vary only little with a change in particle size, accounting for an approximately equal floatability in a large range of particle sizes, as is sometimes the case in flotation. Equilibrium considerations require enhanced floatability of smaller particles, but generally speaking this is not the case. On the other hand larger particles probably do not float because their equilibrium θ is too large and because of the acceleration phenomena investigated by Gaudin. Thus dynamic considerations provide a reason for the nonfloatability of very small particles analogous to the known limits for large particles.

Energy Considerations

It is interesting to compare the kinetic energies of particles hitting rising bubbles at an assumed constant velocity of 30 cm per sec with the amount of energy released by the formation on the air-mineral interface. These computations are shown in Table IV, the decrease in free surface energy being calculated as (area of the interface) x $(1 - \cos\theta)$; θ was taken as 60°. Up to 100 microns, the kinetic energy is larger than the loss in free surface energy, but with particles of 1 micron the decrease in free surface energy is nearly 100 times larger than the kinetic energy. Even for 10 microns the ratio is 1 to 12. This clearly shows that the particle cannot pierce the bubble surface by its kinetic energy alone. This can only trigger the film-recedence, which is governed by forces of much greater magnitude in this range of particle sizes.

Experiments

To check these deductions, experiments were made, using particles within the range of sizes used in flotation, but large enough to give easily measurable times t_c. Regular cylinders were filed from short lengths of steel wire. They were allowed to fall on a captive bubble blown in a cavity bored in a paraffin block. The cylinders were made *hydrophilic* to insure that they did not stick to the bubble but bounced off. This was done by treating them with chromic acid immediately before the experiment.

They were suspended by an electromagnet directly over the captive bubble. When the current was switched off, the general area of the top of the bubble was photographed at suitable illumination with a high-frequency camera operating at about 1000 frames per sec. The film velocity was timed by using a spark discharge of 120 sparks per sec simultaneously photographed on the bubble image. Knowing the diameter of the particle, the magnification could be determined exactly. The evaluation of the film in terms of time-displacement curves was done with a Gaertner spectrum-comparator. The positions of the perforations varied by only a few microns and could be chosen as reference points for the displacements.

The results of the evaluation of one experiment as time-displacement curves are shown in Fig. 2. From these curves the time of contact t_c was determined as shown, the point of departure of the particle from the bubble surface being taken as the point of nearest approach of the curves of the bubble and of the particle. The particle generally did not strike the bubble exactly at the apex, but somewhat in front or behind, so that the instant at which the particle left the bubble was not directly observable. Some particles such as the one in film 6 jumped several times on the surface of the bubble before it finally fell off. In film 3 the velocity of rebound could be measured accurately; it amounted to 56 pct of the initial velocity, corresponding to $\epsilon = 0.44$ in eq 13. In all the cases investigated the vibration of the bubble is not harmonic, and the shape of the curve changes with the number of periods elapsed, as would be expected from the theory. The relative magnitude of the harmonics depends on their relative exitation, i.e. on the exact spot the bubble is hit by the particle. The different particles have widely different energies of impact, controlled by the height of fall h and the mass m of the particle according to the law that energy $= mgh$. The larger the energy, the larger are the induced bubble vibrations and the larger the eventual rebound of the particles. At very high energies the particle pierces the bubble surface.

Table V summarizes the results of the measurements. The size of the particles, the energy of impact, and the calculated and measured times of impact are shown. In the four valid experiments the measured time was about 15 pct longer than the calculated, doubtless due to the influence of the adhering water. This could not be accounted for in the calculations. Such a check is as close as could be expected. These experiments with particles purposely chosen so as to make the time of contact measurable definitely show that the attachment of a particle to a bubble is a high-speed phenomenon and that the times calculated in Table I are a good approximation to those encountered in practice.

The second relation to be investigated was the measurement of the velocity of film recedence with different contact angles and different film thicknesses. This was done by placing a circular polished piece of metal or mineral of about 4 cm in diam on a leveled glass slab in a dish with water or a solution of a collector. By siphoning, the water level could be lowered to give any required film thickness, which remained practically constant during the recedence, as the dish was much larger than the specimen. The thickness was measured by a previously calibrated eyepiece micrometer in a low-power microscope. Through an optical phenomenon the double film

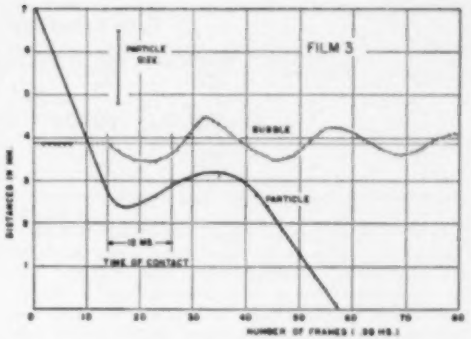

Fig. 2—Evaluation of a collision experiment from the film.

thickness could be measured with suitable illumination. When the required film thickness was attained, a bubble was blown in the center of the specimen by means of a hypodermic syringe reaching into a small central depression bored in the specimen. The time necessary for the water to recede from the center to the circumference of the specimen was determined by means of a stopwatch. The radius, divided by this time gave the velocity of the receding film. Numerous experiments with this arrangement were not quite conclusive. There was a definite increase of the velocity with thinner films, as expected from eq 15. Any other assumed mechanism for film recedence, notably one taking into account the viscous flow, would have given the reverse effect. But the measured velocities, ranging from 0.1 to 20 cm per sec were still about 10 pct of the calculated values, using the magnitude of the contact angle as measured at equilibrium in the bubble machine. It was strange that copper conditioned in a ½ pct solution of sodium Aerofloat gave consistently higher velocities than paraffin or vaseline-coated glass. These experiments must be continued to ascertain the origin of the velocity of the film-recedence. However, it is certain that velocities of the order of 20 cm per sec, as calculated in Table I, are possible. This is true even at film thicknesses of 0.6 mm, probably much thicker than those encountered in flotation. The reader is referred to Table II.

Apparently the discrepancy is due mainly to the value of the contact angle θ used in the calculations. It is well known that an induction time is necessary for equilibrium to develop in the bubble machine. In experiments concerned with high-speed film recedence this induction time cannot possibly be con-

Table IV. Comparison of the Kinetic Energy of Colliding Particles with the Free Surface Energy

Particle, Diam of D, Microns	Kinetic Energy, E, Ergs		Change in Free Surface Energy, Ergs	
1000	2.3		0.28	
500	0.30		0.07	
200	0.018		0.011	
100	0.0023		0.0028	
50	0.30	x10⁻⁶	0.70	x10⁻⁶
20	0.018		0.11	
10	0.0023		0.038	
5	0.30	x10⁻⁴	7.0	x10⁻⁴
2	0.018		1.1	
1	0.0023		0.28	

Table V. Results of Impact Experiments

Film No.	Particle No.	Particle Diam., Mm	Particle Length, Mm	Particle Mass, Mg	Particle Velocity, Cm/Sec	Energy of Impact, Erg	Time of Impact, Calcd./Exper., Millisec	
I	1	0.740	0.930	3.055			11.9	
II	2	0.405	0.560	0.320	9.1	0.013	4.35	~ 6
III	4	0.740	0.770	2.490	17.8	0.40	10.7	12.0
IV	6	0.890	1.040	5.000	24.2	1.46	14.5	~17.3
V	2	0.405	0.560	0.320			4.35	
VI	5	0.508	0.620	1.035	15.0	0.12	7.50	8.5

sidered. How large the contact angle could be under these conditions is as yet unknown. It may be definite fraction of the equilibrium contact angle, but this seems doubtful as seen from the copper-Aerofloat experiments described. It could be that this dynamic receding contact angle, active in the velocity of the film recedence, is only of the magnitude of a few degrees compared to the 30° to 60° equilibrium values. These investigations have yet to be made, but the low values do not seem improbable.

Table II further shows that the minimum film thicknesses for small particles are appreciable fractions of their diameters, so that for particles of only 0.1 micron size the nearest approach is approximately equal to the diameter. It seems unlikely that the initial break of the bubble surface could occur because of surface irregularities of the particle. For particles of 10 microns the film thickness is 10 pct of the diameter and that seems to be the approximate limit to a probable initial break of the bubble surface due to surface irregularities.

The velocities of film-recedence, of the order of 25 cm per sec, are comparable to those measured for the spreading of liquids on water to form surface films. In fact no higher velocities have been found.[16] This would limit the range of flotation to about 5 micron particles under the geometric conditions chosen. On the other hand calculations and measurements of the velocity of bursting bubbles,[17] which were used as a starting point in these calculations, give values up to 3,000 to 10,000 cm per sec. Detailed investigations of these conditions have yet to be made.

The theory developed leads, as has been seen, to a dependence of the contact angle necessary for flotation dependent on the reciprocal fourth root of the particular diameter, whereas statical considerations lead to a dependence on the *square* of the particular diameter. However, should an acceleration of, say, 50 gs be included in the calculations, this would only displace this relationship to higher contact angles not changing its dependence on the diameter. Both relationships can be tested experimentally by making precise measurements of the recovery of a monomineral suspension with exactly known contact angles. Of course, it is very possible that the calculated contact angles of 0.7° to 1.7° are only a small fraction of the necessary ones due to the fact that only idealized conditions can be calculated, and the difference of the static and dynamic contact angles has also to be accounted for. Experiments should not be too difficult to perform.

Summary

A possible mechanism for the attachment of a conditioned mineral particle to a rising bubble has been developed. The time during which the phenomenon occurs is determined by the time of impact, which can be calculated and was substantiated by experiments. During this time the film of liquid between the particle and the bubble must recede, creating the particle-air interface. This velocity of film-recedence has been both calculated and measured and found to be dependent on the "dynamic receding contact angle," which is much smaller than the equilibrium contact angle measured in the bubble machine. This mechanism, as distinct from the static equilibrium, accounts for the more difficult flotation of fines and slimes, and supplements the probability calculations of Gaudin and of Sutherland.

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Thermal Metamorphism and Ground Water Alteration Of Coking Coal Near Paonia, Colorado

by Vard H. Johnson

IN 1943 the U. S. Bureau of Mines undertook drilling in an effort to develop new reserves of coking coal in an area near Paonia, Colo., as a part of an attempt to alleviate the shortage of *known* coking coal of good quality in the western United States. Geologic mapping of the area was undertaken by the U. S. Geological Survey with the purpose of first furnishing guidance in location of drillholes and later aiding in interpreting the results of the drilling.

The drilling program was under the general supervision of A. L. Toenges of the U. S. Bureau of Mines. J. J. Dowd and R. G. Travis were in charge of the work in the field. Geologic mapping was started by D. A. Andrews of the Geological Survey in the summer of 1943 and was continued from the spring of 1944 to 1949 by the writer.

The first few holes drilled failed to locate coking coal, but in the summer of 1944 coking coal was discovered by drilling 6 miles east of Somerset, Colo., the site of present mining. In the succeeding years, 1945 to 1948, 100 to 150 million tons of coal suitable for coking were blocked out by drilling.

The ensuing discussion of the geologic controls on the distribution of coking coal in the area is based on the geologic mapping as well as the drilling done in the Paonia area, more complete descriptions of which have appeared or are in process of publication.[1-3] In order that the possible geologic controls affecting the present distribution of coking coal may be considered, it is necessary to discuss briefly the indicators of coking quality coals.

Coking Coal

Coal that cokes has the property of softening to form a pastelike mass at high temperatures under reducing conditions in the coke oven. This softening is accompanied by the release of the volatile constituents as bubbles of gas. After release of the contained gases and upon cooling, a hard gray coherent but spongelike mass remains that is referred to as coke. This substance varies greatly in physical properties and, to be suitable for industrial use, must be sufficiently dense and strong to withstand the crushing pressure of heavy furnace loads.

Western coals have a generally high volatile content and therefore form a satisfactory coke only when they attain a rather high fluidity during the process of heating and distillation in the coke oven. When this high degree of fluidity is developed, the volatile constituents escape and leave a finely porous coke. On the other hand, when the degree of fluidity is low the product is an excessively porous and therefore physically weak mass that is called char.[4]

Small quantities of oxygen present in coal are believed to decrease the fluidity of the material during the coking process and to favor the development of char rather than coke. In consequence, coal chemists have for some time considered the possibility of developing an index to coking qualities by inspection of chemical analyses of coals.[5]

A formula has now been developed that does permit a rough preliminary estimate of the cokability of coal on the basis of the analysis on an ash and moisture-free basis. Coals may be eliminated as possible coking fuels if the oxygen content is greater than 11 pct. Similarly the ratio of hydrogen to oxygen must be greater than 0.5 and the ratio of fixed carbon to volatile constituents must be greater than 1.3. If the coal, on the basis of these limiting factors, appears to have possible coking qualities, the following formula permits determination of the coking index:

$$\text{Coking index} = \frac{a+b+c+d}{5}$$

- *a* equals 22/oxygen content on ash and moisture-free basis,
- *b* equals two times the hydrogen content divided by oxygen content on moisture and ash-free basis,
- *c* equals fixed carbon/1.3 x volatile matter, and
- *d* equals the heating value on moist, ash-free basis/13,600.

Coking indices higher than 1.0 suggest that the coal will coke, and indices above 1.1 indicate good coking tendencies. Although generally usable, this formula is not completely satisfactory because the percentage of oxygen shown in ultimate analyses is derived only by difference; i.e., by subtracting the sum of the percentages of the constituents determined analytically from 100 pct.[6-9]

Although the coking index indicates the coking tendencies of coal, it is necessary to make physical tests of coke before its industrial value can be determined. The U. S. Bureau of Mines has developed a standard procedure for determining the approximate strength of coke that would be formed from a given coal. In this test one part of ground coal, mixed with 15 parts of carborundum, is baked to form a standard briquette. The weight, in kilograms, necessary to crush the briquette is termed the *agglutinating index*. This test determines the relative fluidity attained in the coking process by measuring the cementing strength of the coal in the briquette. A

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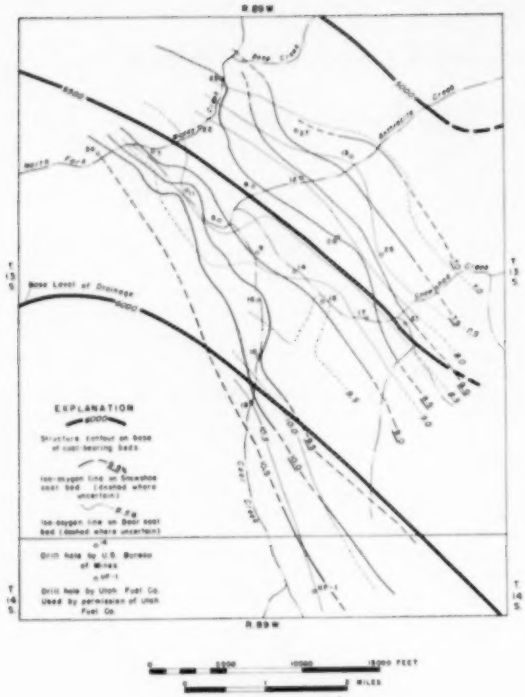
R.89W.
Base Level of Drainage
EXPLANATION
Structure contour on base of coal-bearing beds
Iso-oxygen line on Sneathos coal bed (dashed where uncertain)
Iso-oxygen line on Bear coal bed (dashed where uncertain)
Drill hole by U.S. Bureau of Mines
Drill hole by Utah Fuel Co. Used by permission of Utah Fuel Co.
T. 13 S.
T. 14 S.
R.89W.
FEET
MILES

Fig. 1 — Coking coal area, T.13S., R.89W., Mt. Gunnison quadrangle, Colo., showing drill-holes, iso-oxygen lines and structure contours.

coal having an agglutinating index greater than 2.5 will make coke. Higher indices indicate better coke.

Thermal Metamorphism of Coal

The halos of high-rank coal occur, under some circumstances, adjacent to intrusive bodies of igneous rock. This relationship has been observed frequently in western coal mining districts. The factors that control such local increases in rank are understood in only a general way but appear to be:

1—Regional rank of coal prior to emplacement of the intrusive body. 2—Temperature and composition of the magma. 3—Size and form of the intrusive body. 4—Amount and character of the overburden at the time of igneous emplacement (closed or open system as used in physical chemistry). 5—Distance of coal from intrusive.

In the Paonia and adjacent districts Tertiary intrusive bodies are numerous and several are of large size. These are chiefly quartz monzonite porphyry and kindred types, which locally intrude the coal-bearing Mesaverde formation of Upper Cretaceous age. Small halos of high-rank coal occur adjacent to these intrusions.

An example of such thermal metamorphism may be observed at the Richardson mine on Carbon Creek, 15 miles north of Gunnison and about 25 miles from the Paonia district.[10, 11] A laccolithic intrusive body of quartz monzonite porphyry lies immediately north of the mine and cuts the coal-bearing formation at a low angle. The leading edge extends southward, and at the mine the floor of the main mass lies about 100 ft above the coal bed. This relation is clearly exposed on the west bank of Carbon Creek north of the mine.

Chemical analyses as well as field inspection reveals that in a distance of 2000 ft beyond the flank of the intrusive body the coal varies in rank from semianthracite to high-volatile bituminous. The former evidently is the highest rank that has been reached as a result of the thermal metamorphism, whereas the latter approaches the regional rank of the coals in the Mesaverde formation. Between the two extremes there is an irregular belt of medium to low-volatile bituminous coal that has coking qualities. It is interesting to note that the coal of semianthracite rank is coextensive with the intrusive body where it lies but a short distance above the coal.

In the vicinity of Placita, Pitkin County, Colo., which is approximately 20 miles northeast of Coal Creek, additional evidence of thermal metamorphism has been observed. Coking coal locally occurs in the vicinity of an intrusive body in an area where the regional rank is high-volatile bituminous.

It is rather apparent that local advances in rank, of the types cited, are results of natural distillation of volatile substances, including oxygen, during emplacement of magma masses. In the two cases cited, bodies of higher rank coal thus formed have not been sufficiently altered, by secondary additions of oxygen, to destroy their coking tendencies, in spite of the fact that they lie above the water table. It may be inferred from the above that higher rank coals have less tendency than low-rank coals to absorb oxygen from ground water.

At the Crested Butte mine, 6 miles north of the Richardson mine, the mildly coking medium to high-volatile A bituminous coal lies in a shallow southwest-plunging synclinal trough between semianthracite and noncoking high-volatile coal in the same bed. Semianthracite coal has been produced at several mines northwest of Crested Butte, and noncoking, high-volatile bituminous coal from the old Bulckley mine about 2 miles to the southeast.[12]

In the cases cited above, thermal metamorphism has apparently had a beneficial effect on the coking characteristics of the coal. Contrariwise, the agglutinating index values of the higher rank coal, see cols. 2 and 3 in Table I, from drillhole UF-1 are 0.01 and 0.5, despite the low oxygen content. This coal is from a bed, known as the Oliver bed, that pinches out south of drillholes 18 and 21. Most of the coking coal is in the Snowshoe bed which is about 400 ft lower in the Mesaverde beds. Coal in the Snowshoe bed at drillhole UF-1 contains only 52.8 pct fixed carbon but has 10.2 pct of oxygen and an agglutinating index of only 2.0, see Figs. 1 and 2.

Thick sequences of metamorphosed shale in the northern half of the Anthracite and Crested Butte quadrangles (east of Mount Gunnison quadrangle) indicate the deep source area of the magma which gave rise to the orthomagmatic monzonite intrusions in the West Elk mountains. These latter extend across the southern ends of the quadrangles mentioned and produced little, if any, contact metamorphism of the sedimentary rocks. The higher rank coals at location N, see Fig. 3, in section 20, T. 12 S., R. 88 W. are on the western fringe of the metamorphosed area. The samples represent weathered coal from a stream channel and only proximate analyses were made.

Ground Water Effect on Coals

The present coexistence and relative distribution of coking and noncoking coal within single beds in the Mount Gunnison quadrangle cannot be explained on the basis of thermal metamorphism, dynamic metamorphism, or depth of burial. The difference between coking and noncoking coal in this area is not related to rank. A brief study of the fixed carbon

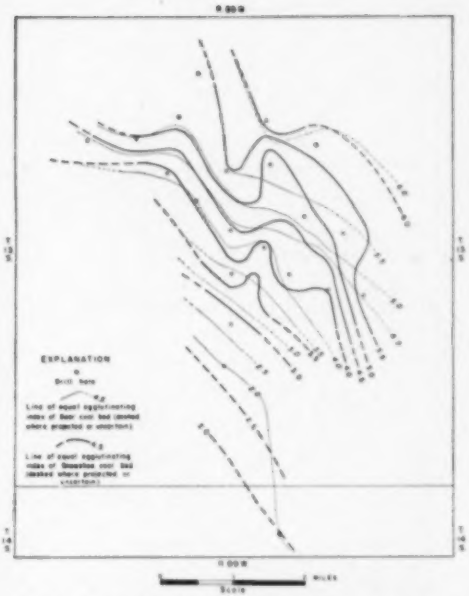
EXPLANATION
Drill hole
Line of equal agglutinating index of Beer coal bed (dashed where projected or uncertain)
Line of equal agglutinating index of Snowshoe coal bed (dashed where projected or uncertain)

Fig. 2—T.13S., R.89W., Mt. Gunnison quadrangle, Colo., showing trend lines of equal agglutinating index in Snowshoe and Beer coal beds.

volatile ratios, Fig. 5, shows that there is no well-defined trend in the very minor variations in rank. Further, the rank of the coal in the Snowshoe bed is essentially average for coal in the West Elk Mountain and Grand Mesa fields. Oxygen is the principal variant and the one most closely related to the coking characteristics of coal in this area. This is in accord with Parry's coking index formula which gives oxygen a triple weighting.

To find the reason for the present distribution of

Table I. Coal Analyses Showing Thermal Metamorphism Due to Intrusions, Moisture-free Basis[a]

Example and Map Symbol	UF-1 (Drill Core)			A		B		C	D	E	N	Regional Avg
	1[b]	2[c]	3[d]	4[e]	4[e]	5[f]	5[f]	6[g]	7[h]	8[i]		9[j]
Distance, ft from nearest contact	0	7+	10	50	400	300±	800±	10±	200±	<1 mile	2000±	
Distance, ft from outcrop	400	450	450	0	0	5	20	40	?	2600	0	
Thickness of intrusive body, ft	16	16	16	2000+	2000+	2000+	2000+	40	1000+	1000+	5000±	
Proximate analysis, pct												
Fixed carbon	83.1	71.7	57.2	75.4	62.2	71.4	56.3	80.5	63.2	61.1	88.4	52
Volatile matter	8.3	21.7	36.2	20.6	33.3	24.2	39.2	14.2	30.7	35.3	7.4	42
Ash	8.6	6.7	6.6	4.0	4.5	4.4	4.5	5.3	6.3	3.6	4.2	6
Sulphur	0.71	0.7	0.8	1.0	0.6	0.65	1.09	0.72	0.44	0.4	0.7	0.8
Ultimate analysis, pct												
Hydrogen		4.9	5.8	4.4	4.9					5.6		
Carbon		87.4	82.5	85.8	78.7					83.3		
Nitrogen		2.1	1.9	2.2	1.9					1.7		
Oxygen		5.9	9.0	6.6	13.9					8.9		12

[a] Other examples may be found in the U. S. Geol. Survey *Bull.* 510. Localities Nos. 79, 120, 121, 127, Floresta, and at Phillip mine. Several analyses of thermally metamorphosed coal are included in the report on Mt. Gunnison Quadrangle and Paonia Coal Fields, being prepared for publication by the author.
[b] Four-in. coal seam at top of 16-ft sill.
[c] Top half of 6-ft coal bed below the sill.
[d] Bottom half of same bed.
[e] Two outcrop samples of same bed.
[f] Second bed is 200 ft above first (U.S. Geol. Survey *Bull.* 510, p. 205).
[g] Coal bed underneath 40-ft sill (U.S. Geol. Survey *Bull.* 510, p. 206).
[h] Location of Richardson mine (U.S. Geol. Survey *Bull.* 510, p. 208).
[i] Crested Butte mine, also in bed between semianthracite and noncoking coal, (U.S. Geol. Survey *Bull.* 510, p. 181).
[j] Regional average for Grand Mesa coal fields.

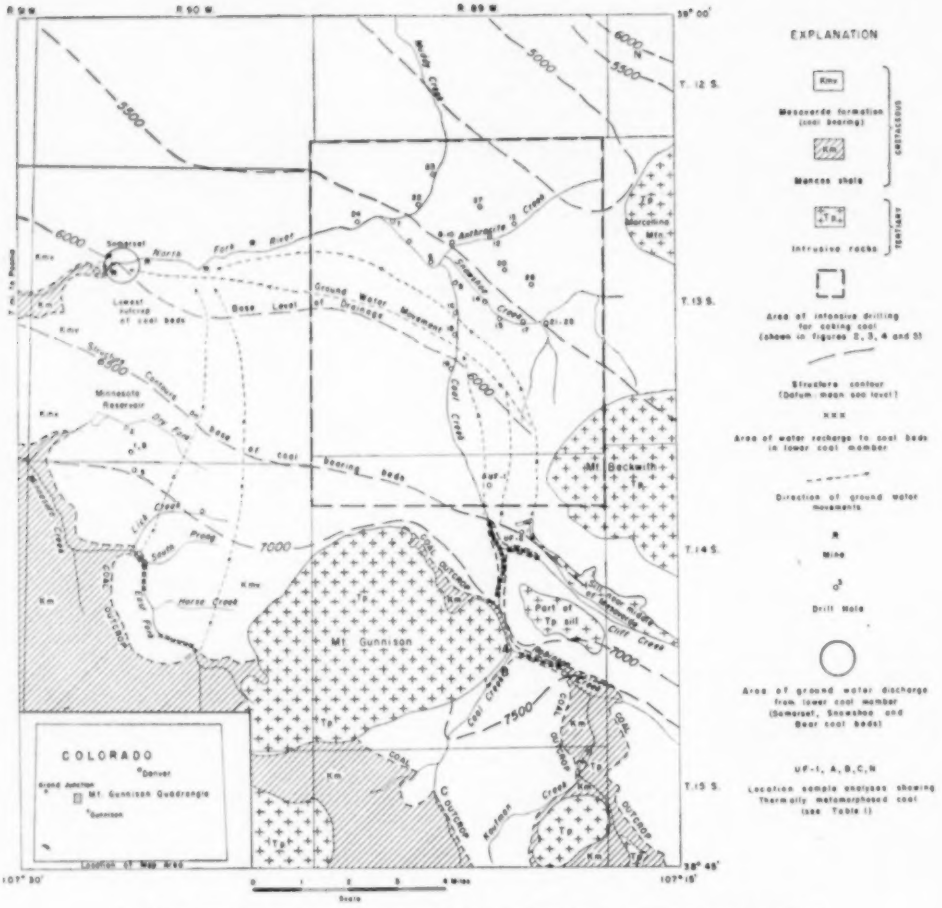

Fig. 3—Mt. Gunnison quadrangle, Colo., showing relations of coal-bearing cretaceous strata to tertiary intrusive bodies and general pattern of ground water circulation at the base of the coal-bearing beds.

coking and noncoking coal, it is necessary to explain the present distribution of oxygen in the coal beds. Analyses of coal from areas above the 6000-ft structure contour, see Fig. 3, show oxygen contents ranging from 10 to 14 pct with a median between 11 and 12 pct (moisture and ash-free basis). In the drill core samples from the area shown in Figs. 1, 2, 4, and 5, the average oxygen content in 44 analyses is 8.87 pct (moisture and ash-free basis) with one analysis showing only 6.8 pct. The reader will note, in Fig. 1, that trends of the iso-oxygen lines representing 9 pct, or less, are approximately parallel to the structure contours. The 10 pct lines rise more steeply toward the east, as might be expected if oxidation were due to ground-water circulation. Lines of equal value for the other variables in the coking index follow similar patterns, see Figs. 2-5.

In the areas where permanent streams and wet gravel lie on the upturned edges of alternating shale, coal, and sandstone beds, the bulk of the ground water enters and percolates through the coal and sandstone beds. The water follows these aquifer beds to the water table and thence along the water table toward the lowest point of outcrop. This point establishes the base level of drainage for those beds, or the level to which the water table would ultimately drop if influent seepage ceased. The gradient of the water table between areas of influent and effluent seepage establishes a hydraulic head, which forces lateral circulation toward the effluent area. Some of this circulation will extend below the base level of drainage, especially near the effluent area. Fig. 3 shows the general structure and pattern of groundwater movement in the Mount Gunnison quadrangle.

It has been shown that the cokability of coal is inversely related, within certain limits, to the quantity of oxygen present in the coal. The proportion of oxygen in coal may be increased by the circulation of meteoric waters. In the zones of downward and lateral movement, such waters are generally aerated and therefore, in percolating through coal beds, provide sources of oxygen that may be absorbed or adsorbed by the coal. This process of alteration may, in fact, increase the oxygen content

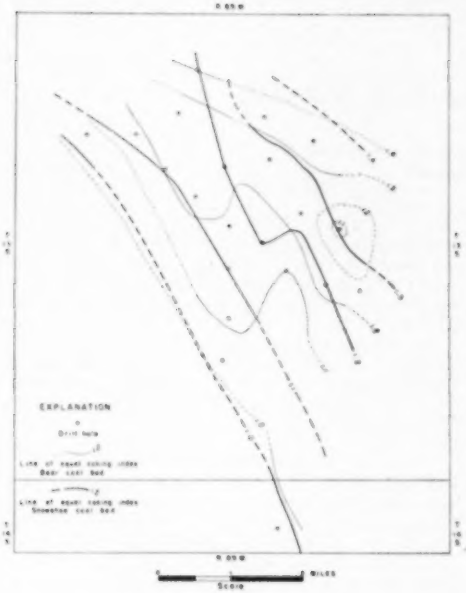

Fig. 4—T.13S., R.89W., Mt. Gunnison quadrangle, Colo., showing trends of lines of equal coking index of coal in the Bear and Snowshoe beds.

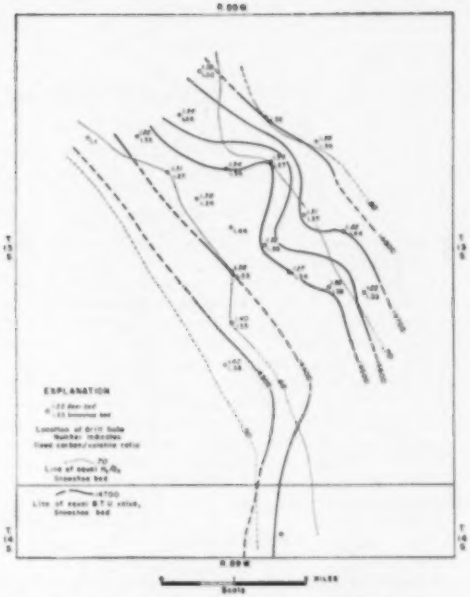

Fig. 5—T.13S., R.89W., Mt. Gunnison quadrangle, Colo., showing values of fixed carbon/volatile ratio for Snowshoe and Bear beds and trends of H_2/O_2 ratio and heat values of coal in Snowshoe bed.

to such an extent that the coal will no longer coke even though it was cokable when the regional water table stood at a higher level and it was below the zone of active ground-water circulation, i.e., an area of stagnant ground water. The addition of oxygen to coal may be expected particularly in the zone of downward percolation of water under climatic conditions characterized by alternate wet and dry seasons. In this zone, where seasonal wetting and drying occurs, oxygen is provided not only by downward-moving ground water but also by air that moves into the space vacated by water moving to lower levels during the dry season. This air is in turn moved downward by the wave of saturation that starts down the coal bed and associated joints and channels during the succeeding wet season. The coking properties of high-volatile western coals may be destroyed for a distance of several miles from the outcrop, if large volumes of water move through the coal bed.

Conclusions

Many factors may, and do, influence the coking characteristics of coal, especially high-volatile coal. The writer has cited several examples of coking and noncoking coal occurring in adjacent areas of the same coal beds. In the cases cited, two geologic processes, thermal metamorphism and oxidation, are believed to be mostly responsible for the present relative distribution of coking and noncoking coal. Thermally metamorphosed coal, of intermediate rank, has better coking qualities than the unmetamorphosed coal adjacent to it and apparently has less tendency to oxidize. Oxygen absorbed, or adsorbed, from actively circulating ground water has apparently reduced or destroyed the coking characteristics of much of the coal in this area.

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Saskatchewan's Industrial Minerals

by A. J. Williams

THE province of Saskatchewan, situated in the center of the Great Plains region of Canada, has, like most prairie areas, an essentially agricultural economy. Most of its population of about 860,000 is located in the southern half of the province in the farming and ranching areas. To the north of the prairie is a broad forested belt supporting a considerable timbering industry, and the northern one third of the province is glaciated pre-Cambrian rock formation. This latter area is relatively barren of vegetation, but the presence within it of a considerable variety of radioactive, noble and base metals, and industrial minerals has been shown by prospecting in recent years.[1]

Glacial Geology

The Keewatin ice sheet, considered to have accumulated in the country to the west of Hudson Bay in Pleistocene time, covered at its maximum advancement almost all of Saskatchewan and extended south of the international boundary. Only in the Cypress Hills in the southwest and around Wood Mountain in the south central portion of the province did the preglacial formations escape the action for this glacial period. The bedrock of the plains and forest areas therefore is overlain by moraines and modified glacial drift, which vary in thickness from a few feet to 400 or 500 ft.[2] Glacial action in the pre-Cambrian area of the province was largely erosional, most of the more recent formations and some of the pre-Cambrian rock being transported out of the area to the south and west. It has been estimated that about 13 pct of this area is composed of lakes and rivers not too adaptable to rail or water transportation, so that until the use of aviation for exploration purposes became general, development of the area was slow. To the south, the heavy mantle of glacial drift has to some extent deterred the discovery of industrial minerals in the bedrock underlying the forest and prairie regions.[3] At the same time, this drift contains numerous deposits of those most elementary and necessary industrial minerals, sand and gravel.

Sedimentary Basin

The major feature of the sedimentary deposits underlying the plains regions is the basinal structure known as the Moose Jaw syncline, which runs from the southeast corner of the province in a northwesterly direction. To the west of this syncline the formations curve upward, then have been faulted and further upthrust to appear at the surface in the foothills of the Rockies in Alberta; to the east and north they curve upward into Manitoba and northern Saskatchewan, but the surface contacts are covered mostly with glacial drift.[4,5] The axis of the syncline dips to the southeast, so that there is also an upward trend of the formations along the axis to the northwest. In illustration of the regional structure underlying the province, the pre-Cambrian *basement* has been logged in drillholes at the following depths in several locations: Ogema (south central), 9390 ft; Gronlid (northeast), 2599 ft; Vera (northwest), 4422 ft; Big River (north northwest), 2348 ft.

Fig. 1 indicates the general surface geology of the province, ignoring such glacial overburden as may overlie many of the bedrock formations. Also indicated is the approximate location of the axis of the Moose Jaw syncline.[4]

Industrial Minerals

Clays: The province is fortunate in possessing a widespread distribution of clays of ceramic value, ranging from those used for heavy structural products to the high grade pottery and china clays. Shales suitable for brick and tile production are found in the Upper Cretaceous and Tertiary formations across the south of the province where the glacial drift is thin or nonexistent. Many deposits of glacial lake clays suitable for such wares are found scattered over the rest of the province south of the pre-Cambrian area.

The Whitemud formation of the Upper Cretaceous is a narrow sedimentary band of secondary clays found intermittently at points across the south of the province where glacial action did not disturb or remove them.[6]

In the southwest corner of the province, around Eastend in the Frenchman River valley, the refractory clays of this formation are contaminated somewhat with iron compounds or other alteration products of basaltic rocks. This eliminates the use of those clays in true whitewares, as they fire to creamy buff shades at the lower temperatures and to a blue-specked grey at cone 8 to 12, (2280°F to 2390°F), the range commonly used in firing whiteware. However, for use in the production of colored artware, caneware, stoneware or crockery, and sewerpipe, this type of clay makes an excellent body that requires little or no addition of flint, feldspar, or other fluxing materials such as are required in the higher class of ware.[7] It is not a grade of clay that can be shipped great distances to the manufacturing centers, but a market for considerable tonnages has developed at nearby Medicine Hat, where cheap natural gas is available for the firing of the ware.

Farther east in the south central portion of the province, the clays of the Whitemud formation are generally more refractory and white burning. The formation is divided into three zones, consisting of white clays, brown shale, and white sandy clays.

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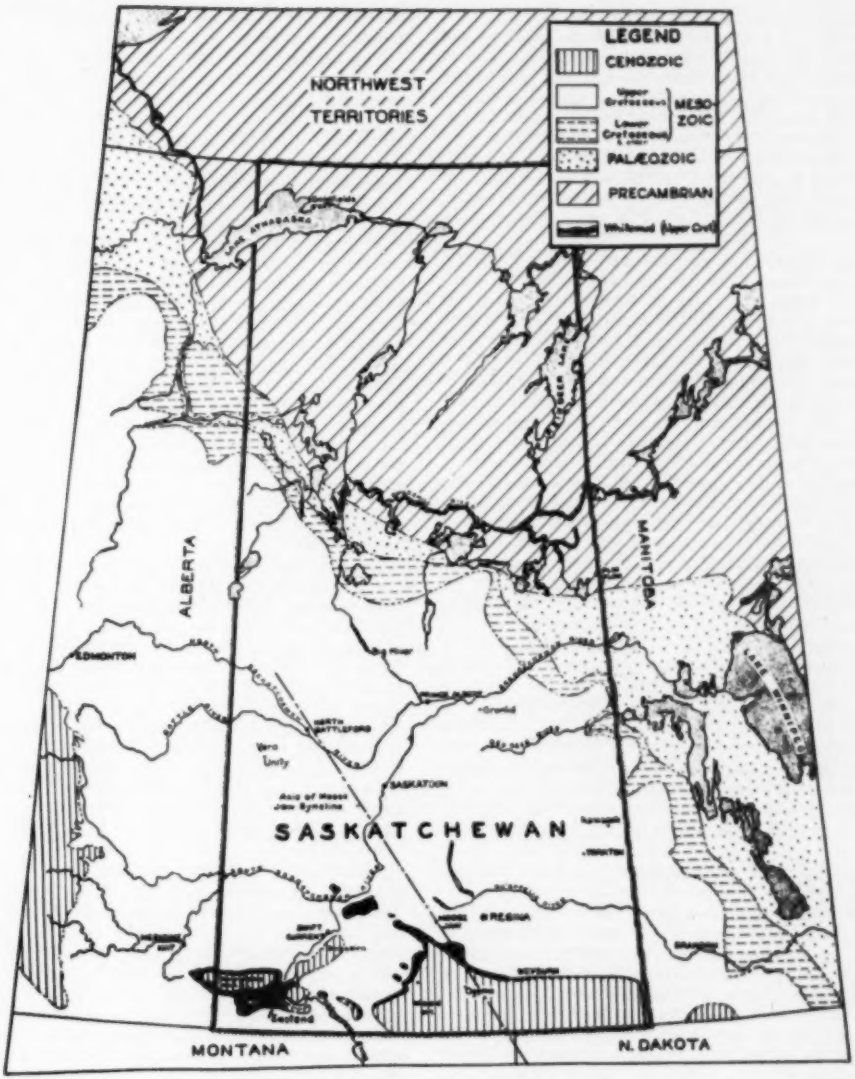

Fig. 1—Geology of Saskatchewan and its environs.

The upper strata of the white sandy zone consists of a weathered breakdown of feldspathic rocks, resulting in an intimate mixture of kaolin or china clay and quartz grains, with some mica and other impurities. This is as a whole a highly refractory clay and has been used to some extent in the production of firebrick. China clays suitable for ceramic use and as fillers in the manufacture of rubber, paper, and other commodities can be separated from this material, but the long freight hauls to the major markets have deterred such development to date. Some test work aimed at bleaching the china clay to a whiteness suitable for coating papers currently is being carried out by the Resources Utilization Branch; if this work is successful, the outlook for production of refined china clay in the province will be improved considerably.

The brown shale above the sandy white zone is moderately refractory but does not burn to a good white color, so is used largely as a component of sewerpipe or firebrick mixtures.

The white clay zone is probably the most important of the three, since it contains valuable white-burning ball clays of exceptional raw strength. A ball clay is a plastic refractory material used in whitewares as a bonding agent for the other nonplastic components such as kaolin, flint, and feldspar. Though it does form a definite part of the

refractory body, its chief value lies in the way it improves the workability of the body mixture and reduces breakage of ware in the handling prior to its being fired. Most Saskatchewan ball clays have greater raw unfired strength than any of the English and American ball clays, and it therefore appears feasible to ship them to the eastern Canadian and American ceramic production centers. To support such development, the Saskatchewan Dept. of Natural Resources has carried out a lengthy program of exploration and testing of all of these refractory clays.

This program has now outlined large commercial tonnages of ball clays, fireclays, and stoneware clays, and the next step, that of carrying forward test work with various ceramic firms to fit the clays to the needs of industry, is going forward at the present time. Reports on the exploration and testing of the more promising clays are available at Regina.[8, 9]

Bentonites: In line with the clay research program, the Department has been investigating reserves of bentonites. These can be used for a great variety of purposes, the foremost being as bleaching agents, as bonding material for foundry sands, and as circulating mud for rotary drilling exploration. While no industry has been based on production of this mineral in the province to date, reserves of over 100,000 tons of high grade montmorillonite bentonites have been proved up and may shortly be providing at least part of the needs of the drilling crews in the present oil and gas exploration boom in Saskatchewan. Work is also being done on some of the nonswelling bentonites for use as bleaching agents. Again, these reserves are found in the relatively unglaciated areas of the south central portion of the province or at more northerly points where river valleys have cut through a thin layer of drift.

Sodium Sulphate: One of the most important surface minerals being exploited in the province today is sodium sulphate, commonly known as salt cake and used in large tonnage by the kraft paper industry.

More than 200 alkali deposits and lakes containing a reserve in excess of 60 million tons of anhydrous sodium sulphate have been located in the province. Their origin is attributed to seepages of water containing calcium and magnesium sulphate through bentonitic clay beds, where an exchange of calcium for sodium ions takes place. The deposits occur in undrained basins, where evaporation over long periods of years has developed the concentration of the alkali salt. In some deposits the salt is present as a strong brine, and in others as a brine overlying permanent beds of solid crystal mixed with varying amounts of clay impurities.

The process of mining and refining the salt cake is relatively simple; the main problem of the industry is maintenance of equipment and buildings because of the corrosive action of the alkali brine, crystal, and dust being handled. In some deposits clean permanent beds of Glauber's salt are quarried and the crystal subjected to a very minor countercurrent washing to remove included silt or clay. To meet the demand for high purity salt, several plants have installed crystallizing ponds. Alkali brine from lake deposits is pumped into these ponds in late summer, when at its highest concentration, and impounded until cold fall weather precipitates the bulk of the Glauber's salt. The supernatant brine then is drained back into the lake, and the clean salt is harvested from the reservoirs with heavy earth-moving equipment.

The balance of the salt cake operation consists of removal of the water of crystallization of Glauber's salt, which amounts to 55.9 pct of the raw material. This is carried out in oil or coal-fired rotary kilns, sometimes preceded by melters and evaporators to obtain greater fuel economy.

Saskatchewan production in the past decade has varied between 100,000 and 150,000 tons of anhydrous salt cake annually.

Magnesium Compounds: Associated with some of the major sodium sulphate deposits is another potentially important mineral substance, a mixture of magnesium chloride and sulphate. Though there has been no development of this resource to date, it could form the basis for an industry producing either the natural magnesium salts or magnesium metal and magnesia refractories, using processes similar to those now extracting magnesium materials from seawater. The magnesium content of the larger lakes is from three to five times that of seawater, while in some smaller lakes up to 4.5 pct magnesium equivalent may be found. A preliminary estimate from a survey of six such lakes in 1950 indicates reserves of over 13 million tons equivalent of magnesium oxide.

Volcanic Ash: Several large deposits of volcanic ash are located in south central and southwestern Saskatchewan. This fine-grained abrasive material has been used to some extent for production of kitchen cleansers; at the present the Saskatchewan Research Council is investigating its usefulness as an additive to concrete for waterproofing purposes. The Department is also trying to develop a cheap process to expand it with heat for use as an insulating material or as a lightweight aggregate.

Analysis of ash[10] from one of the better deposits (Duncairn) is as follows: SiO_2, 68.64 pct; Al_2O_3 and Fe_2O_3, 13.05 pct; CaO, 2.11 pct; MgO, 0.40 pct; Na_2O, 0.91 pct; K_2O, 7.40 pct; H_2O (+105°C), 7.28; and total, 99.79 pct.

Silica Sand, Marl, and Quartzite Pebbles: Among the other quarriable minerals of the province of lesser importance can be included silica sand, marl, and quartzite pebbles. Silica sand from at least one deposit has been tested and proved satisfactory for use as a glass sand and for foundry work, but the market for this material in western Canada has not yet warranted its development.

Chemical and screen analysis of silica sand as mined from the Armit deposit and of a sample subjected to simple Wilfley table washing (85 pct product recovery) have been reported by the Dominion Mines Branch[11] as shown in Table I.

Table I. Analysis of Silica Sand as Mined from the Armit Deposit

Raw Sample				Washed Product, Chemical Analysis, Pct	
Screen Analysis		Chemical Analysis, Pct			
Mesh	Retained, Pct				
20	nil	SiO_2	97.4	SiO_2	99.65
28	15.3	Al_2O_3	0.93	Fe_2O_3	0.027
35	19.2	Fe_2O_3	0.073	TiO_2	0.027
48	21.7	TiO_2	0.056		
65	26.2	CaO	0.043		
100	12.3	MgO	0.086		
150	3.3				
200	0.8				
−200	1.2				

Fig. 2—Saskatchewan salt and potash occurrences.

Several marl deposits have been noted at various points such as Kamsack, Swift Current, and Sturgeon Lake, but have not been investigated to any extent.

The retreating glaciers left numerous eskers of washed and sorted rocks, sand, and gravel in their wake.[1] Among these are several in the southwest portion of the province, which are composed almost entirely of clean, uncemented quartzite pebbles, sometimes used in industry for ballmilling of iron-free materials.

Subsurface Sedimentary Minerals

Salt: From test holes drilled in the search for oil and gas, it has become apparent that a vast salt deposit underlies most of the plains region of the province. Geologists have not yet definitely settled on its age, but it apparently occurs close to the contact between the Devonian and Silurian deposits of the Palaeozoic era.

In the south of the province, at Radville and Ogema, salt beds 250 to 300 ft thick were encountered at a depth of about 7000 ft. More or less following the axis of the syncline, at Davidson two beds totalling about 800 ft in thickness were found at around 5000 ft, and near Unity, further to the northwest, a thickness of 435 ft was encountered at a depth of 3700 ft. A rough estimate of the area underlain by salt is shown on the salt-potash map, see Fig. 2.

To date, one salt plant has been established in Saskatchewan to extract salt from this basin. This plant was built at Unity, where natural gas is also available, in 1947. It is a conventional brine well and triple effect evaporation plant, with a rated capacity of 125 tons per day.

Potash: Associated with the aforementioned salt beds, several occurrences of potash in the form of sylvite (KCl), and carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$) have been noted. At the present time there is no production of potash salts in Canada, and the total annual Canadian consumption, valued at about 4 million dollars, has been imported from the United States and Europe.

While Saskatchewan has the only commercially interesting potash discovered in Canada to date, the depth at which it occurs poses a major mining problem. Potash deposits relative to position in the province are shown in Table II.

Until late in 1950, the occurrence at Vera was the only one which seemed to have commercial significance, and even it was located at nearly 3500-ft depth, compared with the strata being mined at 800 to 1200-ft depths elsewhere in the world. The discovery at Churchbridge in the fall of 1950 has opened up entirely new and perhaps better possi-

bilities. Though at only 500 or 600 ft shallower depth than the Vera potash, it indicates a deposit which may easily extend up the dip of the formations to depths more comparable with conditions in Carlsbad, New Mex.

It is hoped that further drilling in the province will locate potash at shallower levels. The occurrences noted to date are of considerable importance to Saskatchewan and Canada as a whole. Several firms already have expressed interest in the obtaining of exploration permits and production leases on potash areas in the province. It is therefore quite possible that this mineral will be produced, for at least the Canadian market, from these deposits within the next 4 or 5 years.

Surface and Subsurface Pre-Cambrian

The industrial mineral discoveries in the northern pre-Cambrian area have been relatively recent. The search for uranium ores, the provincial government's geological survey, and a Prospector's Assistance Plan have all contributed to a better knowledge of the mineral wealth of this territory. The bulk of discoveries to date have been precious and base metals such as are mined and smelted by the Hudson Bay Mining and Smelting Co., at Flin Flon. This mine takes about 25 million dollars worth of copper, zinc, silver, gold, cadmium, selenium, and tellurium annually from its Saskatchewan orebodies. The complex sulphide ores being smelted at Flin Flon also represent an important potential source of sulphur or sulphuric acid. It is understood that the possibility of recovering such products from the mill and smelter wastes is being given serious consideration at the present time. However, the lack of large-scale nearby markets is an adverse economic factor that may deter such development for some considerable time.

Feldspar: A discovery of high grade feldspar suitable for the ceramic or glass industries was made in the summer of 1950 near Lac La Ronge at the south central fringe of the pre-Cambrian. The discovery is a flat-lying dyke about 4 ft thick, with an estimated 5000 tons exposed at the outcrop. A Dominion Bureau of Mines analysis of a sample from the outcrop indicates that it is a potash feldspar, as follows: SiO_2, 65.14 pct; Al_2O_3, 19.55 pct; MgO, 0.13 pct; Fe_2O_3, 0.04 pct; CaO, 0.20 pct; K_2O, 11.38 pct; Na_2O, 3.52 pct; TiO_2, 0.026; and loss on ignition, 1.11 pct. This is essentially the same type of feldspar produced in vast quantities from the South Dakota quarries.

Asbestos: There have been no asbestos discoveries of commercial significance in Saskatchewan to date, but recent prospecting has uncovered some promising leads. Narrow veinlets of cross-fiber chrysotile asbestos ranging up to ¾ in. in thickness have been found at Ruth Lake near the Flin Flon mine and farther north near Reindeer Lake. The present demand and rapidly expanding market for this mineral has created considerable interest in new finds, and there is little doubt that the Saskatchewan indications will be prospected thoroughly. At present little is known about the extent or importance of these asbestos occurrences.

Limestone: One of the major industrial minerals, high calcium limestone, is missing from the list of Saskatchewan's resources. Dolomitic limestone suitable for building stone and other purposes is plentifully scattered along a broad zone north of the Saskatchewan River, near the fringe of the pre-Cambrian. Much of the boulder deposition over the southern half of the province is the same dolomitic material, so that it appears unlikely that relatively pure limestone will be found in the northern reaches. Limestone beds containing up to 98.7 pct $CaCO_3$ have been noted in cores taken in deep test oil well drilling, particularly in the Devonian formations. It is doubtful if these would be of commercial interest unless mined as a coproduct from a shaft sunk for potash or other minerals.

Table II. Potash Deposits in Saskatchewan

	Depth, Top of Potash Zone, Ft	Bed Thickness, Ft	K_2O Content, Pct
Radville	7653	10½	16.4
Ogema	7420	2½	20.0
	7440	4½	18.6
Davidson	4358	10	10.8
Vera	3466	11	21.64
Churchbridge	About 2800	10	12.7

Conclusion

To summarize the situation, Saskatchewan is blessed with a good variety of important industrial minerals, several of them unique as far as Canada is concerned. Development of some has been retarded because of lack of local markets and complementary industries, others have been discovered too recently to have reached the production stage as yet, and still others have formed the backbone of the province's nonagricultural industry to date. The impetus given to the northern mining industry by recent uranium development, the industrial follow-up to the discoveries of natural gas and crude oil in Western Canada, the availability of vast tonnages of cheap lignite fuel, and the generally expanding usefulness of industrial minerals in the world today are all factors which should shortly bring Saskatchewan's industrial minerals to a proper position of importance in the economy of the continent.

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173rd General Meeting

Photographs courtesy of the International Nickel Co.

Retiring AIME President W. McG. Peirce, left, chats with newly elected President M. L. Haider during a brief respite for both at the Annual Meeting.

LARGEST IN HISTORY

APPROXIMATELY 3500 people thronged the Hotel Statler from February 18 to 24 for the 173rd general meeting of AIME. It was a technical extravaganza in that 82 technical sessions were held, at which 500 authors presented some 350 papers. Fortunately, Jerry Peirce, outgoing President, didn't have to preside at all the events although after his year's stint as President, he has more than a nodding acquaintance with some of the latest problems in the mining, metals, and petroleum industries.

Although the Welcoming Luncheon on Monday noon was the official opening of the meeting, Local Section Delegates and the Board of Directors convened on Saturday and Sunday, respectively. The large attendance and business like demeanor of these two groups was in accord with the energetic and competent service they have rendered the Institute through the year. To the applause of engineers and their wives who thronged the grand ballroom of the Statler for the Welcoming Luncheon, President Peirce introduced Oliver B. Hopkins, president of the Canadian Institute of Mining and Metallurgy and C. Gerow, secretary of CIM. Dr. Hopkins brought greetings from the CIM and expressed his satisfaction in the splendid spirit of cooperation that exists between the two Institutes. Dr. Hopkins is president, Interprovincial Pipe Line Co., Toronto, and counts as a close personal friend M. L. Haider, who is the 1952 President of AIME and lately of Toronto where he was a director and general manager of Imperial Oil Ltd. Mr. Haider will be known shortly as Mike to thousands of AIME members as he makes his Local Sections presidential tour.

There was a pause in luncheon proceedings when Judge Harold R. Medina arrived amid the applause of the audience and somewhat breathless from his trip via motorcade from an antitrust trial against investment bankers at the courthouse downtown. With the Judge at his elbow, President Peirce took the opportunity in his introduction to good humoredly chide the Judge for the vixenish habits of public servants in their treatment of astute businessmen. The successful inventor who patents his inventions is a monopoly; the copper manufacturer who buys his competitors a drink is in collusion; but the business failure need only look to the government for a subsidy, Mr. Peirce pointed out.

Judge Medina quickly captured the admiration of his listeners. He spoke about justice, deploring partisan deals on nominations for judge-

Members of the Mining Branch Council are shown during a meeting at the Hotel Statler. They are, left to right, bottom row: R. E. Byler, E. D. Gardner, John H. Melvin, LeRoy Schoron, R. T. Gallagher, P. J. Shenon, and R. M. Foose; top row: A. B. Cummins, E. H. Crabtree, Jr., J. V. Beall, Ian Campbell, J. B. Morrow, A. Lee Barrett, and R. E. O'Brien.

Mr. and Mrs. J. C. Stipe of Baxter Springs, Kan., plan their schedule for the meeting during a lonely moment on Saturday, before the Section Delegates' meeting.

Sunday brought increased activity with the Education Section cocktail party at the Columbia University Faculty Club. Shown discussing some of the problems expected to arise during the coming week are W. T. Thom, Jr., Harrison A. Schmitt, P. J. Shenon, Father James B. MacElwane, LeRoy Sharon.

ships. With his simple phrases and stirring anecdotes he made his point but, more than that, he renewed the confidence of the people in the integrity of the judiciary.

Four prizes of $100 each were awarded to the winners of the Tenth National Student Prize Paper Contest, at this luncheon. These went to John F. Radavich for his paper *A New Electrolytic Stripping Technique;* Charles R. Rainesalo for his paper the *Tensile Properties of An Aged 31 Pct Cr-Fe Alloy;* Alfred F. Weinberg for his paper *Age Hardening of Copper-Beryllium Alloys;* and William E. Bond for his paper *Some Properties of Silver-Copper Alloys Made by Powder Metallurgy.* Present to receive their awards were Radavich, Rainesalo, and Bond.

The President's banner for the Local Section getting the greatest percentage of new members went to the Southwestern New Mexico Section.

The New York Local Section, seasoned hosts for many an Annual Meeting, set a new precedent for fine hospitality by a cocktail party for all meeting registrants preceding the dinner-smoker on Monday night. The crowd fairly burst the walls of the Sky-Top ballroom, as good fellowship reigned. The generous contributions of mining and metal companies and manufacturers made this affair possible.

The smoker and informal dance on Monday and Tuesday nights, respectively, provided delightful entertainment and conviviality for the many reunions of registrants and their wives from all over the country. One jarring note occurred at the informal dance when, at the request of the band leader, escorts were instructed to lift their partners on

F. R. Morral, Robert H. Dickson, and Oliver C. Ralston are shown at the Monday evening cocktail party held at the Statler. Many at the affair found fellow-members who they had not seen since the last Annual Meeting.

R. Schuhmann, Jr., Allison Butts, and D. S. Eppelsheimer get together at the Education cocktail party for a discussion of the Annual Meeting program.

Mrs. William H. Bassett, past president of the Woman's Auxiliary (1931-33) pours for members and guests during the reception held Monday morning at the Statler.

Ira K. Hearn admires the beautiful silver tray door prize, contributed by John Dorr, won by Mrs. Thorne E. Lloyd, right.

Almost every table was filled for the welcoming luncheon held in the main ballroom of the Statler. Judge Harold Medina was the guest speaker at the affair.

Black tie, gowns and dancing were the order of the evening for the formal banquet and dance topping the week's activities. The affair was held at the Waldorf-Astoria and delegates and wives and friends danced until 2 am.

high. One charming lady received a broken rib from the over-zealous performance of this pleasurable task by her partner.

In an impressive array of dinner attire, members repaired to the grand ballroom of the Waldorf for the Annual Banquet to pay their respects to the new President and award winners. With a firm but easy grace, Jerry Peirce performed his final rites as Institute President. Introducing the award winners, he presented the Robert H. Richards Award to John F. Myers; the Mathewson Gold Medal to C. G. Dunn, F. Lionetti, F. W. Daniels, and M. J. Bolton; the Robert W. Hunt Award to G. Derge, W. O. Philbrook, and Kenneth M. Goldman; the J. E. Johnson, Jr. Award to William R. Bond; the Rossiter W. Raymond Memorial Award to Donald A. Dahlstrom; and a certificate of Honorary Membership to Everette De Golyer. Following this, Mike Haider was introduced as 1952 AIME President. In a few words Mr. Haider expressed his appreciation for the honor bestowed upon him and his intention to make every effort to discharge his duties to the satisfaction of the membership.

At the close of the formal ceremonies Mr. and Mrs. Peirce and Mr. and Mrs. Haider received many hearty handshakes and congratulations. Dancing followed until 2 am.

The Woman's Auxiliary had its usual fine program of meetings and social affairs. During the registration on Monday morning a welcoming reception and coffee clatch was held under the chairmanship of Mrs. Jack Bonardi. While the men were attending the smoker, the ladies had their choice of the theatre or the opera. Tuesday morning, Mrs. Oliver Bowles, WAAIME President, presided at the Annual Meeting of the Auxiliary which was followed by luncheon and a fashion show at the Waldorf. Mrs. Felix Wormser was chairman of the luncheon and fashion show committee.

On Wednesday, the Round Table was chairmaned by Mrs. Roland D. Parks and was followed by a buffet luncheon in the Sky Top lounge, with Mrs. E. H. Robie and Mrs. H. N. Appleton co-chairmen. In the afternoon the ladies went on a tour of the United Nations headquarters.

Thirty-seven students from the Missouri School of Mines attended the Annual Meeting. Transportation via bus was furnished courtesy the Sinclair Coal Co., Kansas City, Mo. Students were selected on the basis of AIME membership, scholastic standing, curriculum of study, and engineering promise.

Of the group, 29 are majoring in mining dept. curricula, mining, mining geology, and petroleum production, 7 in metallurgical engineering, and 1 in geology science. All attended the Missouri School of Mines New York Alumni Section dinner on February 19.

The 173rd general meeting of AIME was the biggest ever held and its great success was made possible by the fine work of the committees of the New York Section and the Woman's Auxiliary. The work of these two groups was under the direction of Francis Cameron, chairman, New York Local Section and Mrs. D. E. Park, general chairman for WAAIME.

Retiring President Peirce, left, and Judge Medina are shown discussing the meeting during the welcoming luncheon. Judge Medina was the guest speaker at the affair.

Members of the Woman's Auxiliary pause for a moment during the reception on Monday morning. They are from left to right: Mrs. O. Bowles, president; Mrs. H. Prosser, past president; Mrs. R. Anderson, president of the Washington, D. C. Section, and Mrs. H. W. St. Clair, recording secretary.

Among those present at the MIED luncheon at the Governor Clinton Hotel were, from left to right, J. D. Forrester, A. Butts, outgoing chairman, and Henry H. Power.

Seated at the head table during the Coal luncheon were Carroll A. Garner, outgoing chairman, A. Lee Barrett, 1952 chairman, and J. B. Morrow.

Student Sidestepping of Mineral Engineering Regarded as Major Problem At Education Sessions

Reported by J. W. Stewart

It quickly developed during the Education sessions that two thoughts are uppermost in the minds of mineral engineering educators. First, and foremost, is the devastating dearth of oncoming mineral engineering students. It was pointed out, as of February 1952, only 1393 college freshmen indicated a preference for a mineral engineering curriculum. This compares with 2238 graduates of the various mineral engineering curricula as of June of the same year. Clearly the graduating class of mineral engineers in 1955 will be entirely inadequate to the nation's needs in that year. Since many of the students enrolled are subject to deferment from military service only until their graduation, the situation with respect to the supply of mineral engineers for civilian needs becomes even more critical.

It was brought out in the discussions that the weak link in mineral engineering education is the lack of contact by the mineral industries with high school students. The suggested solution is the closer relation of personnel representatives of the industry with high school students, and the awarding of financial scholarships in the mineral education field to those found worthy.

Secondly, the fear was expressed that within the foreseeable future this nation will have become a have-not with respect to certain vital mineral resources. In these special categories it was suggested that the importation of metals should be fostered in the interests of conservation in order to face possible disturbances in trade in case of a global war. It was proposed that the United States should go into geo-mineral politics on a world-wide scale, and work out an equitable exchange of the relatively plentiful mineral resources for those in short supply.

Mineral Economics Div. Discusses Foreign Field

Reported by Alan F. Mathews

The United States is becoming increasingly a mineral importing nation, and the best way to promote prosperity is to promote world prosperity, said Howland Bancroft, consulting engineer, in opening the foreign development policies session of the Mineral Economics Div. Experience by the Newmont Mining Co., according to H. DeWitt Smith, shows that the most favorable economic atmosphere for American investment is in the democracies, such as Canada

Sharing the head table at the Industrial Minerals Div. luncheon are Will Mitchell, Jr., H. I. Smith, and R. M. Foose.

A cocktail party featured Monday evening's activities at the Statler. Among the many who attended were H. T. Mudd, left, and Evan Just.

At the Industrial Minerals Div. luncheon, three division veterans seated next to each other recalled many of the past AIME meetings they attended. They are from left to right, Oliver Bowles, James A. Barr, Sr., and R. Smith.

Associate Chairman R. Maurice Tripp and Carl Tolman are shown presiding over a session of the Geophysics Subdivision in the Georgian Room of the Statler.

and the Union of South Africa. Newfoundland is particularly receptive to American capital and the undeveloped mineral potential is great, stated George G. Thomas, consultant, formerly general manager of Buchans Mining Co., Ltd.

About $115 million of United States Government loans are helping to expand mining abroad, reported Charles E. Stott, Defense Materials Procurement Agency. Aside from capital, technical services improving utilization of the mineral resources of Brazil, Bolivia, Colombia, Mexico, Afghanistan, Nepal, India, etc., are being provided by the United States under the Point IV program, explained Alan Probert, U. S. Bureau of Mines, who heads the projects. A noteworthy start in world allocation of scarce minerals and in arresting inflation of mineral prices has been made by the International Materials Conference, according to Edmund Getzin, Dept. of State.

New developments in Canadian mines were outlined by G. C. Monture, Canadian Dept. of Mines; in foreign coal mines by J. W. Woomer, consulting engineer; and in domestic mines by James K. Richardson, Kennecott Copper Corp. The availability and metallurgy of critical materials for jet engines were described, with lantern slides, by Nathaniel Promisel, Dept. of the Navy.

The results of an industry questionnaire on taxation were presented by Granville S. Borden, Standard Oil Co. of California. Industry is making ever greater demands for information on water supply, pointed out A. N. Sayre, U. S. Geological Survey.

Ray E. Byler receives confirmation and degree as a Mill Man of Distinction at the MBD luncheon as the begowned and becapped gentlemen in the picture perform the rites of office. They are from left to right, S. J. Swainson, T. B. Counselman, Byler, J. F. Myers, E. H. Rose, and M. L. Haider, 1952 President of the AIME.

Scots pipers, complete with kilts and toms fill the morning air with Highland music at the MBD Scotch Breakfast. Seated around the table, from the far left, are, R. E. Byler, 1951 Mineral Beneficiation chairman, AIME President Haider, retiring President Peirce, Andrew Fletcher, Don B. Gillies, S. J. Swainson, Bill Stephenson, E. H. Robie, Mrs. Haider, and Stanley Michaelsen.

Keynote of Geophysics Subdivision Sessions Is Active Participation in Discussion by Members

Reported by T. Koulomzine

The Geophysics Subdivision had four lively sessions with a total of 17 papers presented at the New York meeting of the AIME. Attendance at the meetings ranged from 50 to 120. All papers were discussed from the floor and in some cases as many as 15 members participated in the discussions. On Monday afternoon there was a joint session with the Geology Subdivision and 5 papers were presented. The subjects covered ground magnetometer work, electrical methods, and the new method of exploring with radio waves. The emphasis was on the methods of interpretation and on the relationship between geophysics and geology. The paper presented by W. A. Longacre describing the use of the Hotchkiss Superdip as a vertical intensity magnetometer was particularly interesting because it dealt with anomalies as high as 300,000 gammas. Such conditions are confined to iron ore ranges and few geophysicists have had a chance to work with such large anomalies. The new method of exploring with radio waves led to a great deal of discussion. The other papers described case histories of wide interest.

The sessions of Tuesday, both morning and afternoon, dealt with aerogeophysics. An excellent documentary film, made by the USGS, and presented by James Balsley was heartily applauded. H. S. Scott of the Photographic Survey Corp. showed interesting results of combining aeromagnetic and geological studies. W. Dempsey of the USGS and Homer Jensen of the Aero Service Corp. presented two separate papers dealing with the accuracy of airborne surveys, while James Balsley gave examples of correlation of aeromagnetics with geology.

Undoubtedly, the greatest amount of discussion was raised by the paper presented by H. Lundberg, who described a new method of locating oil fields by radioactive measurements taken with a scintillometer carried in a plane. The geochemical phenomena related to this method are yet to be fully explained, but the results are there and they confirm once again the great part which is played in exploration geophysics by wide scope research and pioneering of new methods.

The session of engineering geophysics on Wednesday afternoon consisted of five papers. The wide range of the applicability of geophysics can be judged from the fact that one of the papers written by G. Bodvarsson and presented by S. F. Kelly dealt with geophysical surveys made in Iceland in search for natural steam and hot water, while another paper, by Father Daniel Linehan, discussed not only work in northeastern United States but also the application of seismic measurements to the problems encountered in the excavations under the St. Peter's Basilica in the Vatican City. This paper was accompanied by colored photographic slides.

The distaff side of the Annual Meeting is shown registering on Monday at the Statler for activities, including a trip to the United Nations, a fashion show, a round of luncheons, plays and the opera.

W. B. Plank, left, and F. E. Allen glance up during a chat at the MIED luncheon held in the Gramercy Room of the Governor Clinton.

Geology Subdivision Sessions are Featured By Intensified Interest in Uranium Explorations

Reported by C. P. Jenny

Two morning sessions, both joint meetings with the Society of Economic Geologists, comprised the technical program of the Geology Subdivision. In addition, joint sessions were held with the Geophysics Subdivision on geophysical exploration and with the Mining Subdivision on exploration drilling.

The Tuesday morning meeting, which was well attended was devoted, largely, to lead-zinc deposits. Frank Cameron read an interesting paper, by a group of authors, which dealt with the lead-zinc deposits of eastern French Morocco. This large area is similar in many respects to the Tri-State area and apparently warrants much further exploration and development. Jack James summarized the structural setting of the lead ores of the southeastern Missouri area in a clear and concise manner. This framework was adorned by varying opinions and theories during the subsequent discussion.

A description of the geologic setting of the Nigerian lead-zinc deposits was presented by J. L. Farrington. W. A. G. Bennett then gave a summary of current lead-zinc developments in northeastern Washington. Recent exploration and development activities in this area, and in adjacent portions of British Columbia, have resulted in large tonnages of ore being indicated by drilling on a number of properties. Whether or not more ore is found, the expected influx of geologists and engineers will probably be such that the purchase of one of the local bars or beer parlors would be a sound investment.

L. R. Stieff presented the results of age determination work by the U. S. Geological Survey on Colorado Plateau uranium ores. This work indicated a late Mesozoic age for the uranium mineralization which failed, slightly, to agree with Paul Kerr's Pre-Cambrian age for the mineralization in the Sunshine mine, Idaho. In this connection L. C. Graton is anxiously awaiting a notarized statement from any researcher on age determinations

Retiring AIME President Peirce congratulates Student Award Winners W. E. Bond, second from the left, Charles Rainesalo, and John F. Radovich.

A. F. Taggart of Columbia University, addresses members attending the MBD luncheon.

At a session of the Mineral Economics group, J. L. Head, left, R. J. Lund, associate chairmen, and Allen Matthews, concentrate on the floor discussion while seated at the head table.

Robert M. Chapman, left, of Fairbanks, Alaska, and R. Schuhmann, Jr. were among the section delegates who attended the meeting.

J. J. Norton, R. E. O'Brien, and G. D. Dub were among the diners at the IMD Luncheon at the Gov. Clinton Hotel.

First day's registration at the Statler gave ample evidence that the Annual Meeting attendance would set a new record. About 3500 registrants proved the indications to be true.

from uranium-lead ratios. He pointed out that there had been some suspected variations in the isotope ratios originally thought to be constant. He hopes to assemble a file on this subject which is bound to make interesting future reading.

Paul Kerr did an excellent job of concentrating the attention of the audience on a set of slides which illustrated—with juxtaposition of specimen photographs and autoradiographs—his paper on the uranium mineralization at the Sunshine mine.

At the general session Wednesday morning Harrison Schmitt read J. Hoover Mackin's paper on the Iron Springs district, Utah. Analysis of limestone drill cores indicates that the silica and alumina content variation can be used as an indicator of stratigraphic horizon. Don Davidson outlined the main features of the copper-nickel discovery in the Duluth Grabbro near Ely, Minn. This mineralization in the edge of the grabbro is considered syngenetic in origin and, although low grade, has been encountered in widely separated areas. Property acquisition problems present difficulties and evidently will seriously interfere with further exploration.

Harrison Schmitt suggested more detailed definitions and accurate usage for certain geologic terms now in use. Discussion of the subject was brief considering its scope and the talent on hand. The best suggestion for a solution was the appointment of a committee of not more than one geologist to propose acceptable definitions.

A. P. Butler presented an interesting overall picture of the uranium deposits in the United States as compiled by a number of men on the U. S. Geological Survey. Apparently the deposits of Marysville, Utah, are the most important found to date. Details on the recent uranium developments at Grants, N. Mex., were given by C. C. Towle, Jr. of the Atomic Energy Commission, and F. W. Stead discussed the development and application of airborne radioactivity surveying. It is interesting to note that papers dealing with uranium mineralization, exploration, and development made up 40 pct of the two sessions.

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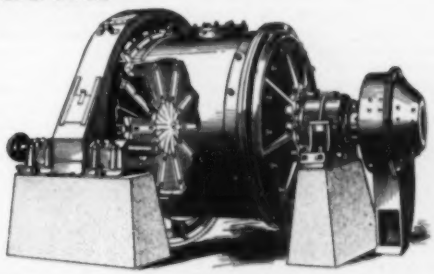

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D. M. Dunbar, left, and Hugh J. Leach presiding as co-chairmen during a meeting on Mining Methods at the Statler.

J. M. Riddell, left, chairman, and L. S. Chabot, co-chairman, listen closely while a paper is read to those attending the session on Drilling.

Gardner Ore Pump Termed Revolutionary by Many In Attendance at SRO Mining Subdivision Sessions

Reported by G. P. Lutjen

At least one old time mining man left Parlor B at the Statler Hotel on Wednesday morning, with near-disbelief mirrored on his face. But most of the men leaving the morning mining session were inclined to be fairly excited about "one of the most revolutionary developments in recent mining history."

Cause of the flurry was Percy Gardner's description of his patented hydraulic hoisting unit at Calumet & Hecla's zinc mine at Shullsburg, Wis. This installation, the first on a commercial basis, is capable of lifting 120 tons of ore per hr, a vertical distance of 365 ft. To do the job requires pumping about 2000 gpm of water. The hoisting column is a 10-in. pipe installed in a shaft compartment.

Ore is crushed underground at the mine to 4 in., but some pieces fed to the hydraulic hoist, are as long as 9 in. The ore pump handles these larger pieces of rock in stride; in fact it has been known to hoist sledge hammer heads and 6-in. pipe couplings.

Guesses of men hearing the paper varied as to the future of this unique hoisting apparatus. The concensus: With perhaps a few refinements, it's here to stay.

But there was plenty besides the Gardner ore pump to talk about for the men sitting in on the mining sessions. The subdivision had gotten off to a flying start shortly after 9 o'clock on Monday morning with a symposium on drilling. By 10 o'clock the SRO (standing room only) sign was hanging on the door.

Occasionally the speakers did bog down in dull generalities, as familiar to their listeners as the backs of their hands. At times they did belabor points better left unbelabored. But by and large, the papers presented brought out some interesting new facts, or at least, martialed previously known facts so as to give clearer pictures of drilling problems and drilling equipment.

Take J. Fred Johnson's paper for example. In stating the case for Coromant equipment in particular, and lightweight jacklegs with integral steel in general, Mr. Johnson has brought together a lot of useful information for anyone considering the use of jackleg machines and integral steel. Here in one paper are the pros and cons. This was printed in the January 1952 issue of MINING ENGINEERING, p. 37.

A contribution to the fund of drill-steel knowledge, was P. L. Russell's progress report on the testing of round carbon steels. One new fact uncovered is that soaking drill steel during tempering does not necessarily result in a metallurgical notch and cause early failure.

The increasing number of papers on foreign mining operations, particularly those in Canada (if Canadian operations can be called foreign), seems like a healthy trend. One U. S. mine operator was heard to remark to a companion, "You know, George; I think we could learn a lot from those boys over the border." This remark may well sum up the reasons for the interest shown in Canadian mining practice.

Public relations as well as mining got the full treatment in Consolidated Mining & Smelting Co.'s moving picture, *No Man is an Island*. This is a four-bell picture—a must for people of the industry from miner to stockholder.

Second half of the double feature came up on Thursday morning; a production on oil shale mining by the Bureau of Mines. This proved to be an excellent picture of the mechanized methods at Rifle that are making production costs of 26¢ a ton possible.

Both of these motion pictures pointed up the value of this medium for telling a story to either lay or technical groups. If management men had noted the earnest attention paid the movies as compared to the polite restlessness during the best of speeches, there probably would be a lot more industrial mining films made. It makes an ideal way to present the picture of the company to the public, miner, stockholder, and government investigator.

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Presiding over the Mineral Beneficiation session are Walter Snavely, left, and Frank R. Milliken.

Dr. S. C. Sun, of Penn State College, demonstrates a process for breaking bubbles with sound during the reading of his paper.

Attendance Continues To Grow at MBD Meetings

Reported by C. L. Sollenberger

The Minerals Beneficiation Div. held eleven sessions at the Annual Meeting, all of which were immensely popular and well attended. A business meeting preceded the sessions at which the reports of the unit operation committees indicated that much new information was being presented and many interesting papers would be available shortly for future meetings. A report of the Special Student Affairs Committee for the employment of students in industry during the summer months indicated that much apathy was encountered, both on the part of professors and men in industry, when these men were contacted to participate in the project. However, chairman Spedden said that a survey showed that both operators and students who had participated considered the work worthwhile and that the program should be continued. The Big Brother project which was started in St. Louis was still alive but was not kicking so noticeably as it was last year.

Conspicuous by his absence at this meeting was past-chairman Grover Holt, who was in the hospital just before the Annual Meeting with an appendectomy.

The first session was a symposium on *What's New in Milling Equipment*. If attendance is a criterion, this was the most popular session of the meeting. The latest information was presented on the Fluosolids roaster and the use of silicon carbide for pump parts. The Wemco attrition machine caused some concern as to whether or not it might be an aerator as well as an attrition machine. Spiral mill liners used to obtain ball segregation in cement plant tube mills a large sintering machine and the application of variable-speed fluid drives to grinding mills were described. With all the controversy over high and low speed rod mills, the use of these drives may be given consideration by more progressive mill men so that they can vary mill speeds at will.

On Tuesday morning at a joint session with the Extractive Metallurgy Div., processes for utilizing domestic manganese ores or improving manganese concentrate grades were described. At a concurrent session on materials handling, papers on conveyors capable of handling hot materials and on high intensity magnetic equipment for protecting conveyors were of particular interest.

Papers describing magnetic roasting of taconite in a shaft kiln, factors contributing to the strength of fired magnetite pellets, and agglomeration by vacuum extrusion were presented Tuesday afternoon.

Two sessions on flotation theory were held concurrently with the operating sessions on Tuesday and Wednesday afternoon. A wealth of information was revealed on reactions at mineral surfaces through the use of radioactive tracer techniques.

One, held jointly with the Industrial Minerals Div., was concerned with desliming and dewatering phosphate sands in a DorrClone, and with the beneficiation of cement rock and rock salt. At the other session, the use of a high frequency siren for breaking down tough flotation froth was described, a flat mill site was shown used to advantage in American Smelting & Refining Co.'s new custom lead-zinc mill at Deming, N. Mex., and two papers on instrumentation were presented.

As an alternate to the second session on flotation theory an operating session on crushing and grinding was provided. The Mardun disintegrator was described with operating data, and an economic analysis of the use of heat treatment to improve the grindability of a taconite was presented. This session closed with a fine description of all types of dust collectors and their application to the mining and metallurgical industries.

On Thursday there were two sessions, one session on crushing and grinding theory in the morning, and the clean-up session in the afternoon. The morning session included a presentation of a paper having the imaginative title, *Progeny in Comminution* which explained how radioactive tracers can be used to aid in solving comminution problems. A film was presented which showed the action of the rods in a rod mill at different speeds. Informal discussions carried over from the Mexico City meeting, were held on the Bond theory of comminution and the subject of overgrinding. Unfortunately illness prevented Fred Bond from being there. The consensus seems to be that the Bond paper is a real contribution to the field of crushing and grinding.

At the Division luncheon, chairman Ray Byler bowed out and Ed Crabtree took the gavel for 1952. Ray was then inducted into that exclusive group of *Mill Men of Distinction* after an impressive ceremony. Professor Emeritus, A. F. Taggart, guest speaker for this luncheon, spoke to a receptive audience about his ideas on education for engineers.

At the clean-up session two papers which could not be presented at the symposium were read, one on continuous weighing on belt conveyors and another on the performance of electrically heated screens.

The growth of MBD was dramatically demonstrated by the large attendance at technical sessions which filled the rooms to capacity and on several occasions overflowed the size of the rooms. More space for future meetings has been assured to take care of this rapidly growing and active Division.

Industrial Minerals Highlight Sulphur, Cement

Reported by H. I. Smith

Of the 36 papers presented by the Industrial Minerals Div., 13 were given in joint sessions. Phases of mineral industry in 17 states were described and references made to information obtained from many other states and countries. One paper was presented by three Finish authors and one by a Canadian author. The average attendance at each session was in excess of 100. The Division also held a luncheon on Tuesday and an executive committee meeting on Wednesday evening.

The first session on Monday morning, with more than 250 present, created the greatest interest from an attendance point of view. The subject was sulphur and sulphuric acid, and papers were presented on sulphur deposits in the Louisiana marshes, native sulphur deposits, pyrrhotite iron ores in Virginia, pyrite in New York State, and the manufacture of sulphuric acid. Information was presented to show that, whereas a shortage of low cost Frasch-mined brimstone exists, other sulphur bearing materials are plentiful, both in the United States and abroad, but involve more expensive extraction processes. Among these materials are sour natural gases, smelter and coke oven

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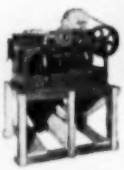
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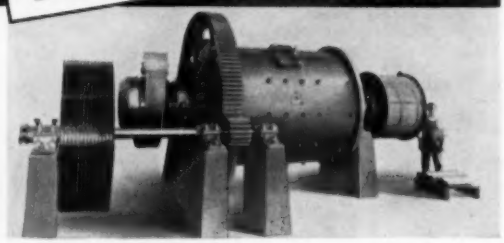

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gases, sulphide and sulphate minerals, particularly the sulphides associated with ore and coal.

The Monday afternoon session was devoted to ceramic raw materials. A paper by Paul M. Tyler presented results of beneficiation of substandard raw ceramic materials and of blending ores to get the desired product. These processes will be of great value to the ceramic industry as the deposits of raw materials are depleted. William T. Bray, Canadian Refractories, illustrated his paper on the *Beneficiation of Magnesite*, by slides showing thin sections of the ore.

The Tuesday morning session was devoted to papers on lime production and the afternoon session to papers on Portland cement. Motion pictures of both industries were shown. Two of the papers presented in the afternoon brought out factors involved in increasing furnace capacity; two related to refractories, and one to dust nodulizing processes. Interest in the subject matter at the two sessions was indicated by higher than average attendance.

The Wednesday morning session was held jointly with the Minerals Beneficiation Div. and included informative papers on chemical analyses of ores containing magnetite and ilmenite, by Errki Laurila, O. Jantti, and R. T. Kukki, Finland Institute of Technology, two papers on beneficiation, one on cement rock, and one on Kansas rock salt.

At the afternoon session, two papers were given on limestone, one on Oregon scheelite, and one on Vermont asbestos.

On Thursday morning, two sessions were held: One a joint session with the Mining Subdivision, and the other a general session.

A paper entitled *Progress Report on Investigation of Northwest Phosphate Deposits*, by R. W. Swanson, V. E. McKeevey, R. D. Sheldon, F. C. Armstrong, E. R. Cressman, and R. A. Gulbrandsen, described the new discoveries of phosphate in the western states. Of particular interest are the vanadium, chrome, and nickel in the ferrophosphate produced by the phosphate furnace operations.

Advancement in science was indicated in papers on specific gravity analysis of titanium, flotation of South Dakota beryllium, and logging drill cores in the Florida land pebble phosphate field.

At the Thursday afternoon session, held jointly with the Society of Economic Geologists, papers on Florida pebble phosphate, bentonite resources, and clay deposits in eastern Colorado gave timely reports on potential reserves. *Wollastonite, a New Venture in Nonmetallic Minerals*, was a paper describing a new source of raw materials for the insulation industry, special tile for sanitary ware glazes, paint extenders, and other uses, and the possible use of some of the impurities occurring with the wollastonite.

Wide Range of Technical Developments Covered As Attendance Record is Set at Coal Div. Session

Reported by D. R. Mitchell

Coal Div. attendance was largest in history with more than 200 at many of the technical sessions and at the annual luncheon. Orville Lyons did a splendid job of arranging a well-rounded program covering geology, mining, preparation, and utilization. The papers were termed excellent, discussions lively, and many expressed appreciation for a stimulating and thought provoking program.

The symposiums on gasification and liquefaction received the widest acclaim. Several members asked whether it would be possible to have these papers printed together in a special volume, for future reference and study.

Many natural gas men were present. Probably a case of 'if you can't beat 'em, join 'em.' Mutual interests between coal and gas men seems to be drawing the two groups together. The possibility of using coal gas to supplement shortages of natural gas in the winter months, and the possibility of transporting coal gas in

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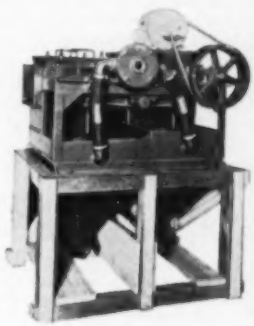

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natural gas pipe lines is receiving considerable study by both groups.

C. E. Lesher's paper on the *Development of the Disco Process of Low Temperature Carbonization* described the historical achievements in developing the process and plant to its present day 1000-ton capacity. Seven process units are in operation. "The record of more than two years' performance of the process units has been particularly gratifying. Unit input in the first year of full operation was 148 tons of dry coal per day, with a yield of over 75 pct commercial Disco and between 16 and 17 gal of tar per ton of dry coal. In 1951 the throughput was increased about 10 pct to 165 tons of coal per day. The yield has been maintained at 75 pct. At this rate of input the daily production of Disco is 860 tons as compared with the design figure of 770 tons."

Special interest was shown in the mining papers on roof bolting and underground auger mining. These are fast growing developments and undoubtedly will receive more use in coal mining.

Orville Lyons' paper on *Comparative Effectiveness of Coal Cleaning Equipment*, designed to promote discussion, created and maintained its objective.

The session on heavy-media cleaning was spirited and emphasized the importance of the medium cleaning circuits in the efficient operation of the process. Hanson and others, in the paper on *Application of Coarse Coal Magnetite Separators In An Existing Circuit* noted: "From 1945 to 1951, there has been an increase of 46.3 pct in the clean coal produced per man-hr. This increase in production has substantially reduced the labor cost per ton and we feel that without the dense-medium vessels, this reduction could not have been made."

Additional Vice-President For Industrial Minerals Div.

At the Executive Committee meeting of the Industrial Minerals Div., on February 20 an amendment of the bylaws of the Division was approved to permit an additional vice-president for the Pacific Northwest. This increases the number of vice-presidents from five to six.

Favorable action was taken on holding the fall meeting of the Division in Chicago during September in connection with the Centennial Anniversary of Engineers.

Several sectional meetings are being planned by the respective vice-presidents of the Division, including one in Canada.

Expressions of appreciation were given to A. B. Cummins, retiring chairman, and the new chairman, Ian Campbell, was heartily welcomed with pledges of support and assistance in continuing the good work on the various phases of the industrial minerals industry.

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aime NEWS

AIME Financial Analysis For 1951 Shows Operating Surplus of $8000, First In 9 Years

Membership at the end of the year 1951 was 19,711 including 2228 Student Associates. The data in the third column include these Student Associates.

1. This includes all the cash dues income received from new and old members of all grades.
2. All cash initiation fees received.
3. Net income received from advertising in the three journals. The figure was $72,273 for MINING ENGINEERING; $39,844 for the JOURNAL OF METALS; and $31,564 for the JOURNAL OF PETROLEUM TECHNOLOGY. Income in 1950 was $54,572, $30,390, and $18,443 from these sources, respectively.
4. Receipts from individual sales, nonmember subscriptions, and multiple subscriptions of members.
5. Includes Transactions volumes and the Petroleum Statistics volume.
6. Sales of all other printed matter except special volumes sponsored by certain Funds. Includes a considerable sale of preprints and reprints of technical papers.
7. Does not include dividends and interest from certain Funds whose income reverts to those Funds.
8. Miscellaneous income not included in any of the above categories.
9. The total income compares with $493,197 in 1950, an increase of $29,000.
10. Consists principally of appropriations made to Local Sections (about $10,000), traveling expenses of delegates to the Annual Meeting, and $866 refunded to Local Sections as representing 10 pct of the initiation fees paid by members in their respective Local Section territories.
11. Includes all appropriations made to divisions and branches and salaries and expenses of paid division and branch officers; also rental for offices used for divisional or branch purposes.
12. All expenses of the AIME Secretary in New York and in the field.
13. Net cost of Annual and mid-year meetings and such other meeting expense as not properly chargeable to branches, divisions, or Local Sections or borne by them. Profits or losses on social functions at all-Institute meetings are for the account of the host Local Section.
14. Net AIME contribution to the support of the Engineering Societies Library. A further contribution to the Library came from interest on the James Douglas Library Fund of $106,000.
15. AIME headquarters occupies 7157 sq ft in the Engineering Societies Building in New York and contributed about $2.40 per ft per year for building maintenance. A small part of this is charged in item 11 for Mining and Metals Branch office space; the rest appears here.
16. Includes the salaries and expenses of the editorial and advertising staffs; paper, printing, and distribution. Net cost can be obtained by subtracting items 3 and 4 from this total.
17. Printing, paper, binding, and distribution of Transactions and Petroleum Statistics volumes.
18. Compiling, printing, and distributing the 40-page directory of officers, committee personnel, Local Sections, Student Chapters, etc. distributed with the journals last spring.
19. Costs of reprints and other miscellaneous publications not otherwise mentioned, or paid for by specific Funds.
20. Salaries and expenses of members of the New York staff not primarily concerned with pub-

INCOME AND EXPENSE STATEMENT, 1951

Income

		Total Amount	Pct of Income	Amount per Member
1.	Dues	$295,348	56.5	$14.98
2.	Initiation	11,054	2.1	0.56
3.	Advertising	143,681	27.5	7.29
4.	Sales journals	22,982	4.4	1.16
5.	Sales annual volumes	23,142	4.3	1.12
6.	Sales other publications	15,864	3.0	0.80
7.	Dividends and interest	4,203	0.8	0.21
8.	Miscellaneous	6,802	1.3	0.35
9.	Totals	$522,076	99.8	$26.47

Expenses

			Pct of Expense	
10.	Local Sections	$14,280	2.8	$0.72
11.	Divisions and Branches	54,011	10.5	2.74
12.	Secretary's expense	2,116	0.4	0.11
13.	Meetings	4,188	0.8	0.21
14.	Library	6,522	1.3	0.33
15.	Building rental	13,035	2.5	0.66
16.	Journals	248,066	48.4	12.58
17.	Annual volumes	36,195	7.0	1.83
18.	Directory	2,194	0.4	0.11
19.	Other publications	7,581	1.5	0.39
20.	General and administrative	46,574	9.1	2.36
21.	Accounting	25,568	5.0	1.29
22.	Membership	22,945	4.5	1.16
23.	Pension	4,387	0.9	0.22
24.	Insurance	505	0.1	0.03
25.	Furniture and fixtures	1,454	0.3	0.07
26.	Depreciation of equipment	12,500	2.4	0.63
27.	Delinquent accounts	3,000	0.6	0.15
28.	Miscellaneous	8,968	1.7	0.45
29.	Totals	$514,067	100.3	$26.03

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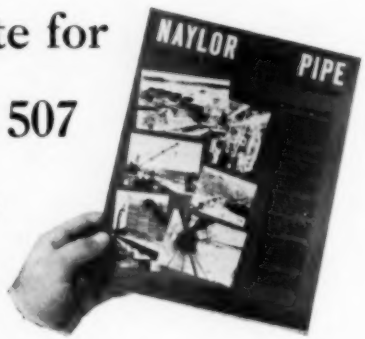

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21. Salaries and all expenses in the accounting dept. at New York.
22. Salaries and all expenses connected with approaching prospects for membership, processing applications, and recording changes of address and title.
23. Cost of noncontributory insurance and annuity policies for AIME employes of more than five years' service. Income from canceled policies redounds to the Pension Fund so this item may vary greatly from year to year.
24. Various types of insurance carried by the Institute.
25. Maintenance of furniture and equipment.
26. Larger than usual because of purchase of new equipment and scrapping old; disposal of unsalable volumes; and adjustments for past years.
27. Reserve set up for probable loss on delinquent accounts.
28. Expense that does not fit into any of the above classifications.
29. Compares with expense of $508,-051 in 1950, an increase of $6016.

It should be noted that the Member and Associate Member paying $20 dues is subsidizing completely the Senior Members (members of at least 30 years' standing and over 70 years old who apply for this grade) and Honorary Members, neither of whom pay any dues but receive all privileges. They also subsidize in part Junior Members, most of whom pay $12; and to a large extent they subsidize Student Associates, who pay $4.50.

Dues Problem Discussed By Board of Directors

Perhaps the most important item on the agenda for the Board of Directors' meeting on February 17 was that of what the policy should be on future dues. Until 1950 the AIME dues were $15 for Members and Associate Members and $10 for Junior Members for the first six years of such membership, thereafter $15. As recommended by the Section Delegates at their meeting in San Francisco in 1949, and as subsequently confirmed by a vote of 78 pct of the voting membership, these dues were raised by $5 for Members and Associate Members and by $2 for Junior Members for the years 1950, '51, and '52 only. In 1953 the dues go back to the former level unless the Directors and the membership, through a referendum, vote otherwise.

The deficit for 1949 was $72,048. With the higher dues schedule, the deficit in 1950 dropped to $14,854. This last year, 1951, in spite of increased costs, a surplus of $8009 was achieved. Two principal factors in the improvement were increased advertising income from the journals, and the fact

that no Directory was published in 1951. The preliminary budget for 1952 shows a surplus of $6000.

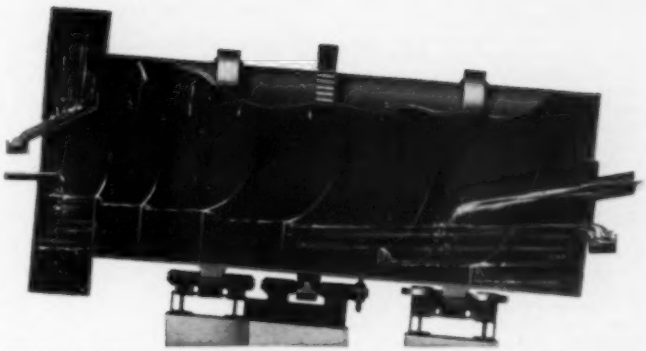
In studying the probabilities for 1953, several factors must be considered. Enrollment of new members should result in an increase in the dues income, and advertising income will also likely increase, as it has done each year since 1949 when the new journals were established. On the other hand, if the value of the dollar continues to decline, unit costs of what the Institute buys will increase. (Based on 100¢ for the 1935-39 dollar, the dollar at the end of 1949 was worth 60¢; 1950, 56¢; and 1951, 53¢.) Further, during the eight years of deficits the Institute's reserve Funds were tapped by an amount exceeding $200,000, bringing those available to meet such deficits virtually to the vanishing point. Prudence would indicate that some restitution should be made to these reserve Funds to take care of possible future requirements. Such restitution must be made from surpluses over the next few years.

Data were presented at the Board meeting indicating that, based on billings for 1952 dues, income from dues payments would be reduced by approximately $69,000 if the dues went back to the pre-1950 level. This would undoubtedly force a radical cut in the services performed, and a reduction in the quantity of published material, with a quite possible resultant reduction in advertising income as well. There was considerable discussion of a proposal from the Petroleum Branch that separate dues be established for each Branch, consistent with providing sufficient income to meet Branch expenses, and allowing a sufficient surplus to pay back the amount taken from reserve funds over a ten-year period. The final vote, with but two or three Directors dissenting, was that an amendment to the bylaws continuing the present dues schedules for all classes of membership be submitted to the membership for a referendum. A statement will be included with the ballot, and published in the journals, as to why it is believed continuance of the present dues schedule is believed to be for the best interest of members.

Bylaw Changes Proposed On Handling of Funds

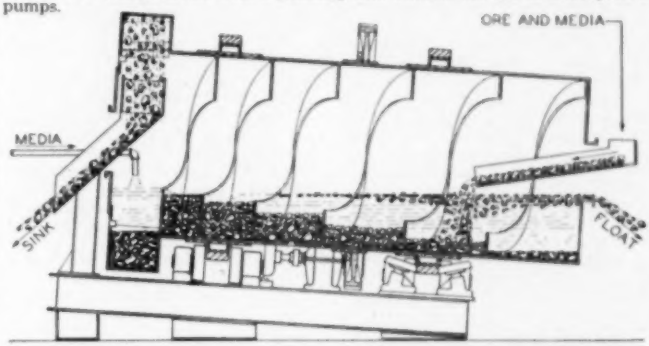
At the meeting of the Board of Directors, AIME, on February 17, the Directors signified their intention of amending Art. VII, Sec. 3, paragraph 3, as follows:

Present wording: "The funds of the Institute shall be paid out by checks signed by the Treasurer and countersigned by the Secretary; in case of absence or disability, the President or any Vice-President may act for the Treasurer, or any Vice-President for the Secretary, but the Treasurer may, at his discretion, place funds of the Institute, not at any time exceeding



CLEANER SANDS-BETTER SEPARATION
with *Counter-Current Classifiers*

The Hardinge Counter-Current Classifier is used for making size separations of ores and sands. It consists of a slowly rotating drum, on the inner surface of which is attached a screw flight. The coarse material is separated from the fines through the action of gravity. The settled granular particles are rolled forward by the screw flight and washed with a counter-flow of wash water. The fines and wash water overflow through an opening at the discharge end. The oversize is elevated by buckets in the enlarged portion and discharged. Operates in closed circuit with a grinding mill without the use of conveyors or pumps.



LOWER POWER-LESS MAINTENANCE
with *Hardinge Heavy-Media Separators*

The Counter-Current unit is also used as a Heavy-Media Separator. The "Sink" is separated from the "Float" as shown in the diagram. The unit has only one moving part, is very efficient and will start up fully loaded. Tramp material will do no harm. Low power consumption. Very low maintenance requirements.

Write for Bulletin 39-B-2, describing the complete line of Hardinge wet classifiers.

HARDINGE
COMPANY, INCORPORATED

YORK, PENNSYLVANIA—240 Arch St. Main Office and Works

NEW YORK 17 • SAN FRANCISCO 11 • CHICAGO 6 • HIBBING, MINN. • TORONTO 1
122 E. 42nd St. 24 California St. 205 W. Wacker Dr. 2016 First Ave. 200 Bay St.

$2500, at the disposal of the Secretary's office for the purpose of paying the smaller current expenses of the Institute and may also establish a payroll account. Such funds shall be banked in the name of the Institute, and drawn by checks signed by any two of the following persons: Secretary, Assistant Secretary, Assistant Treasurer, or Office Manager."

To be revised to read: "The funds of the Institute shall be paid out by checks signed by the Treasurer and countersigned by the Secretary. The Treasurer or Secretary may at any time appoint any officer or employee of the Institute to act for him. In case of absence or disability, the President, any Vice-President, Assistant Treasurer, Assistant Secretary, or Controller may act for the Treasurer and/or the Secretary. The Treasurer may at any time place funds of the Institute not exceeding $10,000 at the disposal of the Secretary's office for the purpose of paying the current expenses of the Institute and may also establish a payroll account. Such funds shall be banked in the name of the Institute and drawn by checks signed by any two of the following persons: Secretary, Assistant Secretary, Assistant Treasurer, Controller, Business Manager, Office Manager."

Notice of intention to amend Art. VIII, Sec. 2, paragraph 3, was also given.

Present wording of 6th, 7th, and 8th sentences: "All bills, accounts, salaries, payrolls, and claims of every kind against the Institute shall be examined by the Finance Committee and be approved by at least one member of the Committee. The Committee shall not authorize any payments in excess of appropriations. If at any time any of the appropriations seem in danger of being insufficient, the Finance Committee shall report the same to the Directors."

To be revised to read: "All bills, salaries, accounts, payrolls, and claims of any kind against the Institute within the approved budget of the year shall be examined and approved by the Secretary or such officer or employee of the Institute whom he may designate. Any such payments not included in the approved budget shall be examined by the Finance Committee and signed by at least one member of the Committee. The Committee shall not authorize any payments in excess of appropriations. If at any time any of the appropriations seem in danger of being insufficient, the Committee shall so report to the Directors."

The above suggested changes will be acted upon by the Board at its meeting on April 16.

Proration of New Members' Dues Proposed by Council of Section Delegates

A proposal emanating from the Council of Section Delegates in 1951, that dues of new members be prorated according to the number of months remaining in the calendar year following the date of election, was favorably regarded by the Directors at their February 17 meeting. They recommended a change in the bylaws to make this effective. It is therefore proposed to change Art. II, Sec. 2, 3d sentence as follows:

Present wording: "Members, Junior Members, or Associate Members elected on or after June first of any year shall pay, on receipt of Treasurer's statement, one half of said amount for the year of election, and if elected in the month of October, November, or December, the candidate may defer acceptance to the first of the following year without loss of status."

To be revised to read: "Newly elected Members, Associate Members, or Junior Members shall, on receipt of Treasurer's statement, pay the current year's dues on a pro rata basis for the number of months remaining in the calendar year following the month of election."

It is expected that the amendment will be voted on at the meeting of the Board on April 16.

Charge for Arrears In Dues To Be Cancelled

Hereafter, Student Associates and Junior Members who have been dropped from the AIME rolls because of arrears in dues will have such arrears canceled if they are obligated to pay an initiation fee. If such persons have passed their 30th birthday they must be reinstated as Associate Members or Members and are thus liable for the $20 initiation fee, though it may be paid in $5 annual installments. The Board, which took the above action at its meeting on February 17, felt that a charge for arrears in dues in addition to the initiation fee and current dues was too much of a hardship. Reinstatement of other members who had heretofore paid an initiation fee is made without any charge except for current dues unless they were in arrears for dues when their membership terminated, in which case the arrears must be paid, but not in excess of $20.

Recommend Increased Representation on Board

A proposal originating last year with the Mining and Metals Branch Councils, that Branch Council Chairmen be ex-officio members of the AIME Board of Directors was regarded favorably by the Board at its meeting on February 17. This had been advocated also by a special Committee on increased divisional representation on the Board, John R. Suman, chairman. This committee had also recommended three-year terms for Divisional representatives, instead of the present one-year term for Divisional Chairmen, but the Board took no action on this part of the Committee's recommendation.

To effect the proposed change, the Directors, at their meeting on April 16, will vote on the following change in Art. VI, Sec. 1:

Add the words in italics: "The number of Directors of this Corporation is 27, consisting of one President-elect, one Past President, six Vice-Presidents, and 18 other Directors, to be elected as hereinafter provided: and in addition the Chairman of each duly constituted professional Division *and of each Branch Council* of the Institute, ex officio, shall serve as a Director, with full voting power, during his term as Chairman, *provided, however, that such ex-officio Directors shall have but one vote if they are already duly elected members of the Board.*

"At the regular November meeting of the Board of Directors or Executive Committee, the chairman therefore shall declare to be elected, as provided in Art. IX of these Bylaws, nine Directors, of whom one shall also be designated as President-elect, and of whom two shall be designated as Vice-President. The nine Directors, including the Directors designated as officers, together with the newly elected Division *and Branch Council* Chairman in their capacity as ex-officio Directors, shall take office at the annual business meeting of the Institute next following the meeting at which they were declared elected . . . "

SuperDuty
DIAGONAL DECK
No. 6
CONCENTRATOR
TABLE

SuperDuty
Tested and Proved

SuperDuty Diagonal Deck Concentrating Table fundamentals have been proved by years of hard use. The Diagonal Deck, the Anti-Friction Bearing Head Motion and the Factory Aligned Undercon-struction are tested features operatively combined for generous working margins over rated performance standards. Production records may be checked in hundreds of installations. Write for Bulletin 118B.

THE DEISTER CONCENTRATOR COMPANY
The Original Deister Co., Incorporated 1906
923 Glasgow Ave. Fort Wayne, Ind. U.S.A.

Fall Meeting Date Set

The Fall Meeting of AIME will be held Sept. 3 to 6, 1952 in Chicago with headquarters at the Palmer House. These dates fit into the Chicago Centennial of Engineering Program, which is being held from July 1 to September 30. It will be possible for any division to have technical sessions on September 4 and secure a limited number of rooms at the hotel for Wednesday night, September 3, and Thursday, September 4.

Drilling Symposium To Be Held in South Africa

A diamond drilling symposium will be held April 21 to 23, at Johannesburg, South Africa, under the auspices of the Chemical, Metallurgical and Mining Society of South Africa.

Papers are scheduled on drilling practices in the United States, Northern Rhodesia, Canada, Australia, and South Africa.

Tuesday, April 22, those attending the symposium will visit a South African gold mine during the early part of the day. During the final day of the meeting, a visit has been arranged to the Premier mine, Transvaal. Arrangements have also been made for an air trip to Welkom, Orange Free State, Friday, April 25. Tours are scheduled to the Diamond Research Laboratory; Johannesburg, Kimberley, Cape Province; Ndola, Northern Rhodesia; Rhokna, Nohanga, Mulfulira, and Roan Antelope mining and metallurgical plants, with a stop at Victoria Falls, and a motor trip to Kruger National Park. Visitors will be notified of cost of field trips in the near future. The technical sessions will be concluded by a cocktail party. All sessions are scheduled for the Kelvin House.

1955 Annual Meeting

An invitation to hold the Annual Meeting in Chicago in 1955 has been accepted by the Board of Directors. Unless otherwise determined by the Board, the dates will be February 14 to 17.

Reduce Number of Endorsers Needed For Junior Members

To ease the transition from Student Associate to Junior Member, the Board of Directors, at its meeting on February 17, proposed that the bylaws be changed to reduce to one the number of endorsers needed by graduating students in applying for the higher status. The Student Associate would be sent an application blank immediately on leaving school. This would be endorsed by one member, but not the same member who originally endorsed him for Student Associateship. The Admissions Committee would act upon this application and if their recommendation was favorable the Board would elect the applicant to Junior Membership at the end of the year, when his Student Associateship would expire. He would then be billed for the succeeding year's dues as a Junior Member. To permit this change in procedure, the Board will vote, at its April 16 meeting, on the following change in the pertinent bylaw, Art. I, Sec. 9, first sentence:

Present wording: "Every candidate for election as a Member, Junior Member, or Associate Member must be proposed for election by at least three Members, Junior Members, or Associate Members, must be approved by the Committee on Admissions, and must be elected by the Board of Directors, and not less than three fourths of the votes cast shall be necessary to election."

To be revised to read: "Every candidate for election as a Member, Junior Member, or Associate Member must be proposed for election by at least three Members, Junior Members, or Associate Members, provided, however, that in the case of a Student Associate applying for Junior Membership only one proposer in addition to the member who nominated him for Student Associateship be required. All candidates for election to membership must be approved by the Committee on Admissions" . . . etc. as above.

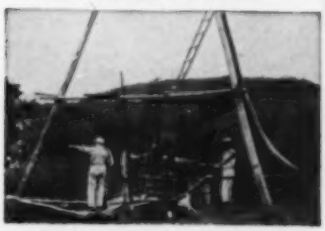
Longyear and IRON ORE DEVELOPMENT* have progressed together for 60 YEARS!

E. J. Longyear drilling first diamond drill hole on Mesabi Iron Range in 1890.

*BUT . . . iron ore is only one of our interests. Since our first diamond drilling contract in 1890 (see top illustration) Longyear equipment, crews, engineers and geologists have been employed from sweltering Africa to the Arctic Circle; from mountainous Venezuela to bleak Labrador. They have successfully explored for all kinds of minerals from asbestos to zinc.

LONGYEAR'S world-wide experience in contract drilling, shaft sinking, mine development and geological investigations can help you solve your problems. Longyear also manufactures a complete line of diamond core drills and equipment.

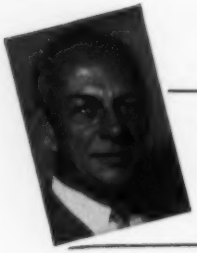
• *Write for new General Bulletin 83.*



LONGYEAR contract drilling crew prospecting for iron deposits in Venezuela.

Exploring for iron ore in Canada with a LONGYEAR UG Straitline Drill in 1950.

E. J. LONGYEAR COMPANY
MINNEAPOLIS, MINNESOTA, U. S. A.
DIAMOND CORE DRILLS • CONTRACT CORE DRILLING • SHAFT SINKING
GEOLOGICAL INVESTIGATIONS



THE DRIFT OF THINGS

by Edward H. Robie

IN many ways, the Annual Meeting of the Institute in February was the most successful yet held. Attendance surpassed even that of the 75th Anniversary Meeting in 1947 with its international flavor. The number of technical sessions and the number and quality of papers presented almost certainly set a new record. The banquet was the best attended of any yet held even though the price reached a new high. Despite the demand for almost 1700 tickets to the banquet, some felt that the price—$13.50—was higher than they could afford. There are two points of view: One is that this is the big social event of the year for members and that it is worth from three to five dollars more to have it at the Waldorf and to have a luxury menu, as we did this year, with turtle soup, a fish course, guinea hen for the entree, and wild rice (which we understand is $3.50 per lb) for a vegetable. The other point of view is that a seven or eight dollar banquet of more simple food at the Commodore Hotel would more than make up in appeal, especially to the younger and less well-heeled members, what it would lack in glamour.

Men's Registration at Annual Meeting

N. Y.	641	England	10
Pa.	429	Idaho	9
N. J.	160	Kans.	9
Ohio	132	Germany	8
D. C.	113	Nev.	8
Ill.	111	N. Mex.	8
Mass.	98	Ariz.	6
Canada	95	France	6
Conn.	93	Mexico	6
Mo.	84	Belgium	5
Texas	58	Vt.	4
Mich.	56	N. H.	3
Md.	34	Oreg.	3
Calif.	33	S. D.	3
Del.	33	Ark.	2
Minn.	31	Neb.	2
Colo.	28	Sweden	2
Utah	25	Wyo.	2
W. Va.	25	Alaska	1
Ala.	24	Argentina	1
Okla.	23	Chile	1
Tenn.	21	Cuba	1
Wis.	21	Colombia	1
Ind.	18	Ga.	1
Fla.	17	Liechtenstein	1
N. C.	12	Me.	1
Ky.	11	Miss.	1
Mont.	11	Nigeria	1
Va.	11	N. D.	1
Wash.	11	S. C.	1
La.	10	Venezuela	1

Total men's registration—2578

Though meeting rooms were not entirely adequate for all of the technical sessions this year, the idea of transferring the meeting to Atlantic City, with more commodious quarters, got no support whatever. The feeling of western members seems to be that if we come East then let's go to New York and not to a summer resort in the winter time.

Those who came from particular states and countries may be interested in knowing how well their home land was represented at the meeting. The data, taken from the list of men actually registered at the meeting, are shown in the accompanying table. Without making too accurate a survey it would appear that of AIME members living within a 50-mile radius about 50 pct came to the meeting; 50 to 500 miles, about 35 pct; 500 to 1000 miles, 18 pct; and 1000 to 3000 miles, 4 pct.

Every state was represented except Iowa and Rhode Island, and 14 foreign countries were named on the registration cards.

For those who couldn't make it, remember Los Angeles, Feb. 16 to 19, 1953.

Fireside Incident

The mistress of the house, who was napping in the living room the other evening, suddenly woke up enough to inquire, "What's that noise?" "I am merely," we told her, "tearing out some of the advertising pages in the last issue of *Life* in order to get at the reading matter and pictures." "That's silly," she said, "and anyway, you shouldn't be one to object to advertising, for that pays part of your salary, and you are always saying that that's what you need more of." "But our kind of advertising is different. For one thing, it's not all mixed up with the leading articles to distract the reader's attention. And for another thing, it contains a lot of useful information and news about the latest developments in machinery which, if we were operating men, it would be in our interest to read."

"Now take these 42 pages we have just torn out. Fifteen of them, or more than one third, are advertising liquor."

"Since when have you ceased to have any consuming interest in liquor," we were queried.

"Since our cupboard became well stocked," we replied. "And we don't believe that these brands are necessarily noted for their quality. For instance, six pages are devoted to advertising mixtures of whiskey from 60 to 70 pct alcohol, though you would never guess it from the ad. The word 'alcohol' is never mentioned once. Then there are four pages of cigarette advertising, and it must be ten years since we smoked a cigarette. And if we did take up the habit we doubt if the advertisements would give us much of a clue as to which one we like the best. We suspect that not only is cigarette smoking a habit but that the brand one smokes is equally a habit."

"I think I'll go back to sleep. That is, if you are through tearing paper."

So we stopped, and while we were thinking about the matter, browsed through the advertising pages of ME, JM, and JPT, as we call them for short. We didn't find them in the middle of an article, and we found them interesting and instructive. The next time we meet an operating engineer, we believe we can talk to him a little more intelligently.

Personals

B. G. Anderson and **J. E. Hill**, U. S. Bureau of Mines, have just returned from Yugoslavia where they were consulting for the Yugoslav Government with reference particularly to the Bor and Trepca mines. This work is part of the technical assistance program.

Frank A. Ayer, Copper Range Co., has been named chairman of the alumni special gifts committee for mining and metallurgical engineers in the Columbia University Engineering Center Development Fund.

Eugene C. Anderson recently has been appointed to a six year term as vice-chairman of the State Economic Development Commission, New Mexico. He is also representing New Mexico on the Water and Minerals Resources Committee of the Arkansas - White - Red River Basin studies being conducted by the Inter-Agency Committee of the Army Engineers and U. S. Bureau of Reclamation.

L. M. Becker has been appointed superintendent of Pickands Mather & Co.'s new West Hill mine on the western Mesabi, Minn.

T. H. Cain has retired as assistant superintendent of the Godfrey underground mine, Oliver Iron Mining Div.

A. M. Dixon is mine superintendent at Gabbs, Nev., for Basic Refractories, Inc.

Avery A. Drake, Jr. is now a member of the mineral deposits branch, U. S. Geological Survey, Denver.

George C. Earl, chief engineer, Utah Copper Div., Kennecott Copper Corp., has retired. He will be succeeded by **L. C. Jones**, who has been assistant chief engineer.

John H. Eggers, Los Angeles, has been elected president of the Mining Assn. of the Southwest for 1952.

Alwin F. Franz has been elected president of the Colorado Fuel & Iron Corp. **Carl W. Myers**, who has been president since 1946, was elected vice-chairman of the board of directors.

T. Bartow Ford, manager of international sales, the Dorr Co., Stamford, has been promoted to vice-president in charge of sales and elected a director. **J. Delano Hitch**, formerly vice-president in charge of sales has been promoted to the position of executive vice-president.

George R. Fisher, general manager of operation of the Zinc Corp., Ltd., Broken Hills, New South Wales, Australia, has accepted the position of vice-chairman of Mt. Isa Mines Ltd., Queensland, Australia.

RICHARD M. FOOSE

Richard M. Foose, professor and head, dept. of geology, Franklin and Marshall College, has been designated by the Board of Directors of the Mining Branch Council, to represent the AIME at the 19th International Geology Congress in North Africa this summer.

Delmar H. Larson, formerly with the National Lead Co., has opened his offices in Los Angeles as a consulting chemist and chemical engineer and patent agent. Mr. Larson was with the Baroid Sales Div. for 15 years, and was director of research and more recently manager of the patent dept.

Paul Linz has resigned as chairman of the board of South American Minerals & Merchandise Corp. He plans to spend a portion of each year in Mexico. His permanent address is South Kent, Conn.

Domingo Moreno recently resigned from the staff of the American Smelting & Refining Co. to join Singmaster & Breyer, consulting engineers, New York. Mr. Moreno is a native of Chile and has had extensive experience in plant design and construction in the United States and Latin American countries.

Walter Rukeyser, consultant in mining and processing asbestos, has left for Belgrade, Yugoslavia, to appraise the value and uses of that country's asbestos deposits.

William W. Wanamaker, Brigadier General, U. S. Army, retired, has been appointed chief engineer for the Orinoco Mining Co.

William J. Wiley has been elected to the board of directors and appointed financial vice-president, Atlas Powder Co., Wilmington, Del.

As Originators of Rivetless Chain, Wilmot Offers Widest Choice of Chain Sizes and Conveyor Attachments

The booklet contains engineering data on rivetless chain in pitches from 3" to 10¾" and working loads from 3,000 to 130,000 lbs.; of drop-forged steel, alloy or cast chrome-manganese steels. Wilmot not only stocks the largest choice of chain sizes, but also furnishes the widest range of other conveyor parts: sprockets, traction wheels, flights, take-ups, shafting, bearings and trough in cast iron, ductile iron, carbon or chrome-manganese steel to fit the application. See why an increasing number of leading firms are cutting "down" time by depending on Wilmot for all conveyor replacement parts.

WILMOT ENGINEERING CO. HAZLETON, PA. *Foundry and Shops:* WHITE HAVEN, PA.

Obituaries

Robert W. Pringle (Member 1902) of Salisbury, Southern Rhodesia has died. Mr. Pringle was educated at the Edinburgh Collegiate School, Edinburgh; University of Edinburgh; and the Meyer Institute Solothurn, Switzerland. He also took a course in mechanical engineering at the Heriot Watt College in Edinburgh. Several years later he attended the Royal School of Mines, London and was awarded the De La Beche medal in mining, the government prize, and associateship, first class. He was in South Africa as surveyor and mining engineer for several companies. In 1902 he was engaged by the Velardena Mining & Smelting Co. in Mexico. Some time was spent as assistant engineer to the Ecuadorian Assn. where he made a mineral examination of Ecuador. Mr. Pringle came to the United States in 1920 and was engaged as mill superintendent for the United Eastern Mining Co., Oatman, Ariz. He became mill superintendent for the Benguet Consolidated Mining Co. in Baguio, P. I.

Sibyl Walker Smith (Member 1921), Salt Lake City, died on Dec. 7, 1951. Born in Salt Lake City, Mrs. Smith graduated from Massachusetts Institute of Technology in 1918 with the degree of S.B. In 1921 she was residing in Pittsburgh and three years later returned to Salt Lake City.

Appreciation of Theodore Zuschlag

By Hans Neubert

On Monday evening the 12th of January my very best friend and our esteemed member Theodore Zuschlag by his own free will left this world to find peace and rest in the great beyond. Whoever had a chance to get into contact with him—be it personally or professionally—will appreciate the great loss we have suffered by his death. He was known in this country and overseas for the great improvements that he carried through in the field of nondestructive analysis as well as in the field of geophysics. He reached only the age of 56 years and much could the engineering profession still have profited by his research and knowledge, if fate would have given him a few more years to live.

Born and educated in Germany he had a master's degree in electrical engineering from the Dresden University. After a few years of research work in Germany he came to this country in 1925 where he was busy in the field of geophysics first with the Institute for Geophysical Exploration in Texas and later with the Taumac Corp. of New York. From 1928 on he continued his activities in the same field with the Swedish-American Prospecting Corp., of New York. During the depression he changed over to the Magnetic Analysis Corp. where his creative imagination and his great professional skill was responsible for the development of this company. Numerous patents, taken out until recent years, bear witness to the deep knowledge and creative thinking with which he was endowed. In recognition of his services he was made vice-president of the Magnetic Analysis Corp. It is very notable that besides his connection with the nondestructive analysis field, he still kept his interest in geophysics and that up to his death he was director and technical consultant of Hans Lundberg Ltd. of Toronto.

As great as the loss is to the engineering world just as deeply is his passing felt by his friends and before all by his family to whom he always was a devoted father. If by his death he spread grief and sadness among his friends, I am sure that he has suffered unbearably before his end. Though through all his life he lived and worked for his profession, we all know how much he enjoyed in his quiet way the numerous pleasant things that grow along our road of life. How proud was he to show the wonderful pictures that he brought home from his numerous trips, how glad was he when he could be a gracious host to the ever present crowd

Here's Your Bit Service for ECONOMICAL DRILLING Of Prospect Test Holes . . .

Exploration drillers everywhere have proved that Hawthorne "Blue Demon" Bits efficiently drill 75% of the medium and hard formations encountered. Drillers save on roller and diamond bits, particularly in sandstone and cemented formations.

"Blue Demons" surpass all similar bits in drilling exceptional footage and holding gauge size in harder formations . . . because of superior design and manufacture from drop forged alloy steel faced with diamond-like tungsten carbide, heat treated for toughness. Each bit finger cuts only a small part of the hole and takes only a small part of the load.

These same "Blue Demons" drill soft formations far faster than conventional bits, resulting in faster drilling, fewer round trips and lower costs.

•

Use "Blue Demon" Rock Cutter Bits, with replaceable blades, in sizes from 1⅞" to 10", for COAL, OIL and MINERALS EXPLORATION . . . TESTING and CORING . . . WATER WELLS . . . GROUTING . . . and FOUNDATION testing.

Drillers the world over are drilling faster, with fewer bit changes, at reduced drilling costs, with long lasting Hawthorne "Blue Demon" Bits.

Use "Blue Demons" for rock bit efficiency at "fish tail" cost.

PATENTS PENDING

Write for Illustrated Catalog

HERB J. HAWTHORNE INC.

P.O. BOX 7388, HOUSTON 8, TEXAS

of friends who gathered under the roof of his house.

Even though we cannot enjoy any more his presence among us, the memory of this rich and gentle soul will be with us for the rest of our life.

NECROLOGY

Date of Election	Name	Date of Death
1937	Sam S. Coldren	Feb. 10, 1952
1915	Nelson Dickerman	Feb. 18, 1952
1939	George E. Steudel	Jan. 16, 1952

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Feb. 29, 1952 was 17,221; in addition 7,341 Student Associates were enrolled.

ADMISSIONS COMMITTEE

T. D. Jones, Chairman; Thomas G. Moore, Vice-Chairman; H. S. Bell, F. W. Hanson, R. H. Chadwick, T. W. Nelson, C. A. R. Lambly, John T. Sherman, A. C. Brinker, G. P. Lutjen, Ivan Given, E. A. Prentis, C. Leslie Rice, Jr., and J. H. Scaff.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Bessemer—Bailey, Andrew V. (J) (C/S—S-J)
Birmingham—Andrews Joseph W., Jr. (J) (C/S—S-J)

Arizona
Bagdad—Campbell, John B. (M) (R, M)
Ray—Hasemeier, Thomas G. (A) (R, C/S—S-A)
Safford—Tompkins, F. Varnon (M)
Superior—Botkin, Thomas Gayl (M)

California
Arcadia—Rodolf, Ray Harry (M)
Darwin—Davis, Jr. William B. (J) (C/S—S-J)
Whittier—Clark, Ralph I. (A) (C/S—S-A)

Idaho
Deary—Smith, Albert K., Jr. (J)
Kellogg—Kinas, Thomas D. (J) (C/S—S-J)
Osburn—Gould, Wayne D. (M) (R, C/S—J-M)
Wallace—Lathrop, Jr. John S. (J) (C/S—S-J)

Illinois
Findlay—Keim, John T. (J) (C/S—S-J)

Kentucky
David—Crawford, William (M)
Greenville—Sorrell, Sherwood W. (J) (C/S—S-J)

Maryland
Rainier—Warde, John M. (M) (R, C/S—S-M)

Michigan
Alabaster—Sieh, Clayton, J. (J) (C/S—S-J)
Calumet—Gabel, Gerald R. (J) (C/S—S-J)

Minnesota
Hibbing—Eaton, Jr. Lucien (M)

Missouri
St. Louis—Jones, Berkley (A)

Montana
Butte—Anderson, John R. (J)

Nevada
Gabbs—Hanson, Norman E. (M)

New Jersey
Maplewood—Marshall, Elgin J. (M)
Ridgewood—Dickey, George D. (M)

New York
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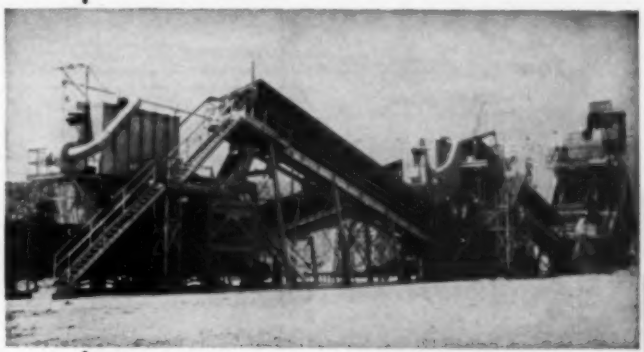

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Coming Events

Apr. 9, AIME, Chicago Section, Chicago Bar Assn., 29 S. La Salle St., Chicago.

Apr. 11-12, Geological Society of America, Cordilleran Section, annual meeting, University of Arizona, Tucson.

Apr. 15, AIME, Morenci Subsection, Longfellow Inn, Morenci, Ariz.

Apr. 15-17, AIME, South West district meeting, Jefferson Hotel, St. Louis, Mo.

Apr. 17, AIME, Utah Section, New House Hotel, Salt Lake City.

Apr. 21-23, American Zinc Institute, annual meeting, Hotel Statler, St. Louis.

Apr. 21-23, Chemical, Metallurgical, and Mining Society, and **Diamond Drilling Research Laboratory**, symposium on diamond drilling, Johannesburg, South Africa.

Apr. 22, Assn. of Consulting Chemists & Chemical Engineers, Inc., general symposium, Hotel Belmont Plaza, New York.

Apr. 25-26, AIME, New England Regional Conference, Kenmore Hotel, Boston.

Apr. 26-May 11, Liege International Fair, Liege, Belgium.

May 4-8, Electrochemical Society, Inc., Spring meeting, Benjamin Franklin Hotel, Philadelphia.

May 5-7, American Mining Congress, coal convention, Netherland Plaza Hotel, Cincinnati.

May 6-9, Scientific Apparatus Makers Assn., annual meeting, Edgewater Beach Hotel, Chicago.

May 9-10, AIME, joint meeting, Industrial Minerals Div. and Metals Branch, Davenport Hotel, Spokane, Wash.

May 11-14, American Institute of Chemical Engineers, Atlanta Biltmore Hotel, Atlanta.

May 17, AIME, Chicago Section, President's night dinner dance, Shoreland Hotel, Chicago.

May 27, AIME, Morenci Subsection, Longfellow Inn, Morenci, Ariz.

June 2-4, Chemical Institute of Canada, annual conference, Montreal.

June 6, AIME, Columbia Section, dinner meeting, Spokane Hotel, Spokane.

June 16-20, American Electroplaters Society, Industrial Finishing Exposition, International Amphitheater, Chicago.

June 23-27, ASTM, 50th anniversary meeting, Hotel Statler, New York.

July 1-Sept. 30, Centennial of Engineering, Chicago.

Sept. 3-6, AIME, fall meeting, Palmer House, Chicago.

Sept. 11-13, American Institute of Chemical Engineers, Palmer House, Chicago, Ill.

Sept. 22-25, American Mining Congress, Metal and Nonmetallic Mining Convention and Exposition, public auditorium, Denver.

Sept. 23-25, Institution of Mining and Metallurgy, symposium on mineral dressing, Royal School of Mines, London.

Oct. 3, AIME, National Open Hearth, Southern Ohio Section, Deshler-Wallick Hotel, Columbus, Ohio.

Oct. 20-22, AIME, Institute of Metals Div., fall meeting with National Metal Congress, Hotel Adelphia, Philadelphia.

Nov. 19, American Mining Congress Coal Div. Conference, Wm. Penn Hotel, Pittsburgh.

Dec. 4-6, AIME, Electric Steel Furnace Conference, Hotel William Penn, Pittsburgh.

Dec. 8, AIME, Arizona Section, all-day meeting, Tucson.

Feb. 16-19, 1953, AIME, annual meeting, Statler Hotel, Los Angeles.

Apr. 20-22, AIME, National Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Hotel Statler, Buffalo.

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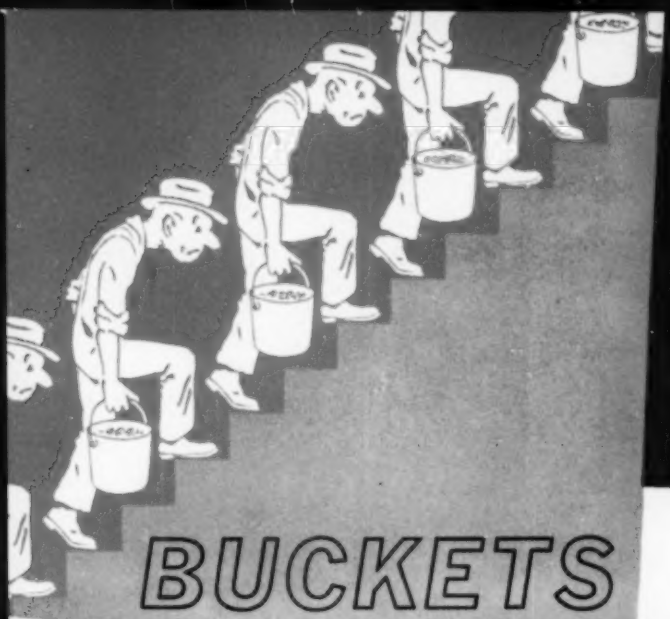

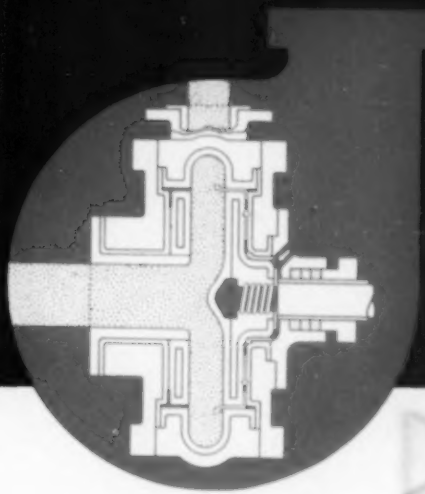

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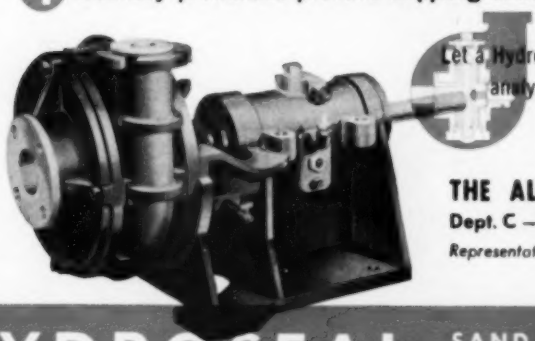

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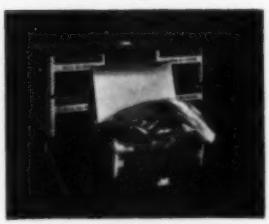

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